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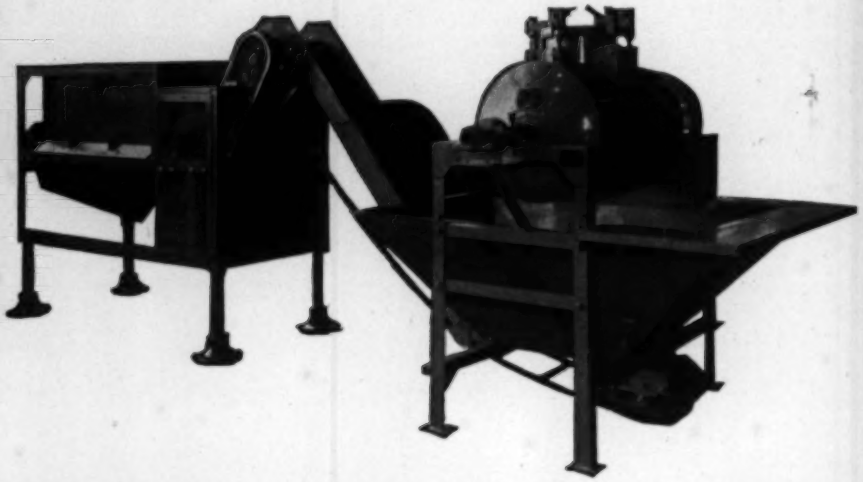

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The Food Technologist and the World Food Crisis[a]

The object of this conference is food production. It is then only proper that we begin by taking stock of the world's food production situation.

As food technologists, we can be proud of the fact that, with a bit of luck, the world will in 1949 produce more food than it has ever produced before. But, since the purpose of food production is to feed people, it is proper that we consider also the world's food consumption situation. We will then see that there is nothing to be proud of in the world's food situation, because the world will in 1949 have many more undernourished or even starving people than it had before the war. This may mean that, in spite of bumper crops in many countries, and in spite of all the magnificent efforts in agriculture and food industries, the world's food situation is worse than it has ever been before, at least apart from war years.

This sad situation is due to the fact that food production has now barely surpassed the production in pre-war years, but, in the meantime, the world's population has increased 10 percent. So there is effectively 10 percent less food to go around.

Perhaps it is misleading to use the war years, with all their disruptions, for comparison. Let us then look at the prospects. To maintain the level of nutrition which we had before the war, the world must by 1960 produce 25 percent more food than it produces now.

A 25 percent increase in ten years is a very high target. Such an increase, however, has been achieved before. Great Britain and U. S. A. and Canada reached it during the war years. That was due to favorable weather conditions, very favorable prices, and a supreme effort. Most people doubt that this high production can be kept up.

It is not a question of keeping it up, however, it is a question of increasing it another 25 percent. Experts agree that this cannot possibly be done in these countries and if it cannot be done there, the chances are even slimmer that it can be done in technically less advanced countries.

Nevertheless, let us for a moment be optimistic. Let us suppose it were done. Where would we then be? We would then have the same level of nutrition as we had before the war. This means that half of the total population of the world would be under-nourished—and large numbers actually starving.

We certainly should try to avoid this. But then, it is not a 25 percent increase at which we are aiming. It is rather a 50 percent increase. To reach such a production by 1960 would be extremely difficult and it would require an entirely new approach. Unless it can be done, nature will of necessity have to use her own old remedies. These are starvation, epidemics, and wars. This means that a great many of the world's most urgent problems can be reduced to this: How can we provide a bowl of rice or some slices of bread for those 55,000 more people the world will have at its dinner table tomorrow than it has today?

Humanity must find a solution for this problem. It is a concern of all countries and all governments. Because of the gravity of this problem, the governments created F. A. O., the Food and Agriculture Organization of the United Nations.

This is a world organization, designed to look after the world's food supply. But this is a very big problem for a small organization, and we are only a small organization. Our yearly budget is about four and a half million dollars,—less than that of many state agricultural colleges in the U. S. A. And the field in which we have to work is not a state, but the whole world. Therefore, what we in F. A. O. can do is very limited. It is very limited unless we can obtain the cooperation of the people in every country in the world—cooperation to conserve and use food to better advantage, and cooperation to produce more food.

More particularly, we must obtain the cooperation of all those who are directly concerned with food production, distribution and consumption. We are extremely thankful to you, therefore, for having shown such an interest in our work that you have invited someone from F. A. O. to speak to this highly qualified audience—an audience which includes experts from every conceivable branch of the food industries, in one of the greatest food producing countries in the world. We sincerely hope that this will provide opportunity for increased future cooperation.

The question would then be: What can the American food technologist do to improve the world's food situation? He—or she—of the U. S. A. would first look at his own country and would realize that it has already done remarkably well. It has, admittedly, still some problems, and it has many people whose nutrition still needs improvement. But, with regard to the basic question—that of simply producing enough food to go around—your problems have to a large extent been solved.

What about exports, then? If the world needs more food, the U. S.A. could produce more for it. You all know that this could be done, technically. You also know that the needy countries could not afford it. India, for instance, has lately relied much on imports for her food supplies, but her funds for imports are running low. The same is true of Europe. It is doubtful whether or not Europe will be able to even keep up her present imports of food from North America, when funds, allocated under the Marshall plan, expire.

It may sound strange, but the fact remains that the American food industry could probably do more for the food supplies of the world by importing more foods. This sounds like taking the food away from needy countries. The reason is, of course, that the U. S. A. would mainly import higher valued or highly specialized foods, that are often difficult to use locally, and exports to the U. S. A. would put the countries in a position to import much larger supplies of cheaper food stuffs.

[a] Presented at the Ninth Annual I. F. T. Convention, San Francisco, July 11, 1949.

For instance, Peru, during the war, established a considerable tuna—or, rather, bonito-canning industry. Practically the total production is exported to the U. S. A. These canning activities have even taken some food away from the local population, because they led to an increase in the price of raw bonito. Local consumption of tuna, therefore, decreased. Nevertheless, this industry has made it possible for Peru, as a country, to import more food and food producing machinery. Thanks to the canning activities, many individuals in Peru can now afford larger and better food supplies.

This development was largely aided by North American experts and it is an excellent example of the numerous cases where American food technologists actively contributed to the developments in other countries.

Such exports to the U. S. A. would be possible in many other fields. Countries have often tried and failed—sometimes because their products were not good enough; but sometimes, because they lacked experience in marketing in U. S. A., or they did not understand your pure food laws, etc. There the American food technologists can assist greatly.

But is this not against the interest of the American food industry? In some cases it may be at least against the interest of some branches of it, as all new developments may be. But it is not against the interest of the U. S. A. The example of Peru is an illustration of the fact that this is one world; this is one world in which no one country can exist alone. The economy of the U. S. A. is to a certain extent based on exports. These exports must be balanced by imports, but Peru, as well as almost all other foreign countries, has difficulty in finding funds with which to pay for their imports. Peru has such difficulty that she already has to restrict very seriously her imports from the U. S. A. If she did not have the canned fish exports, she would be forced to cut imports even more.

Such developments would hurt American exporters. And they would do even more. They would cause serious economic difficulties in foreign countries—so serious that they would lead to political difficulties, spread to other countries, and even result in wars. This may sound exaggerated, but I can assure you, from personal experience, that the foreign exchange situation is getting serious in many countries. Therefore, we must aid trade between the nations; especially, in the most important of all commodities—in food.

Is there not anything which the American food technologist can do to help other countries improve their own food supplies? There certainly is. Many parts of the world have a great need for technically trained personnel to help improve their food processing and food preservation. It would be of immense value to such countries if some of the vast American experience in this field could be made available. As most of you already know, a program of this nature was suggested by President Truman in his inaugural address.

As point four in this address, the President called for a bold new program for making the benefits of the scientific advances and industrial progress available for underdeveloped areas. The aim of this program should be to help the free peoples of the world through their own efforts to produce more food, more clothing, more materials for housing, and more mechanical power. The President suggested that all nations should work together—through the United Nations and its specialized agencies—in such a world-wide effort for the achievement of peace, plenty, and freedom.

Following this, the government of the U. S. A. and the Secretariat of the United Nations have outlined such programs. We in F. A. O. have prepared our part and we have placed a great deal of importance on it, because we feel that the world is faced with a grave food crisis. We must, therefore, utilize every possibility to attain the greatest international cooperation in the field of food and agriculture.

It is proper to mention that such a program would only mean a continuation of work which is already begun. The U. S. A. has for many years assisted other countries with technical experts, technical publications, scholarships, etc. Federal expense for such programs has been estimated at about three million dollars yearly. Other nations have done the same, although on a smaller scale. The United Nations did much in this field through UNRRA, and is now doing it directly, or through many of its specialized agencies.

We, in F. A. O., are trying to do our share, but we can do only a fraction of what we find need for, and only a fraction of that for which we have well justified requests. It is for that reason that we can assure you that there is great need for such work. It is also for that reason that we hope that these activities can be increased. Especially, then, will the American food technologists be able to contribute much.

It may be justifiable at this point to sound a warning. It is not always an easy thing to give technical assistance. I think that one is too often confronted with the opinion that what technically under-developed countries need, is just more "know how." If they only knew how to produce more food, how to process food better, etc., then they would do it. So, therefore, all they need are technical experts to tell them how to do things.

It is unnecessary to say that this is incorrect. When we talk about under-developed areas, it is necessary to consider all the factors that may be involved, and not just the possible lack of "know how" because progress can be achieved only after all obstacles are removed. One will often find that the real difficulty is not a lack of technical knowledge, but a lack of financial possibility for bringing it into use.

For instance, in the Santa Cruz region in Bolivia, an extensive plan has been made for sugar growing and processing. Bolivia has large imports of sugar which she can hardly afford. Calculations have shown that sugar could be produced cheaply enough in Bolivia. Therefore, such production would be profitable, not only for Bolivia as a country, but also for the individual investor. The plan is ready. It is a sound investment, and yet it has so far not been possible to have this project financed.

It may in many cases not be a great investment that is needed. Maybe it is just a farmer who needs some fertilizer. The fertilizer might greatly increase his

production. Still, he may have no way of getting money with which to pay for it. Or, it may be a case such as that of a fisherman I heard about in Venezuela. He had been fishing for over thirty years. He had a lot of experience, and he was hard working. He had always wanted an engine on his boat, but he had never been able to earn enough money to get one. Then a special credit system was set up. This system helped him to get an engine, and he was able to pay back the full amount in a few months—simply because his catch was more than doubled. Here it was not "know how" which was needed; it was just a credit system. A small short-term loan could double production. What was needed was, first, some capital, second, some expert advice to say where it could best be used.

You may recall that President Truman in his inaugural address referred not only to technical assistance, but also to efforts to facilitate investments in foreign countries. I believe that in many cases this is more important than assistance with "know how," and that the U. S. A. and American industry can contribute much by helping to solve this part of the problem.

Secondly, the lack of "know how" may not be on a very high technical level. For instance, thirty million tons of grain is lost in storage every year. This would be sufficient to form the basic diet of one hundred and fifty million adults. Yet, the question is not so much a matter of refined preservation technics. It may be that the individual operator is not sufficiently aware of the fact that insects breed in cracks in the floor, that one infested flour bag may infest many, etc.

Actually, this is more a question of extension service than of expert technical assistance. Of course, such assistance may be needed in the setting up of an extension service system.

Now suppose, for instance, that the producer in some country had the necessary capital, and suppose he had, or were supplied with, the necessary "know how." Could he then go ahead and produce more food?

The answer depends first on the consumer's desire to use that food. It may mean that the consumer would have to change his food habits. And as almost every food technologist knows, this requires much time and effort, especially among less educated people. Their traditions, religions, and even superstitions play a large part. In addition, their daily diet is, for the most part, extremely simple. Their knowledge of various cooking methods is therefore very limited. Also, their kitchen utensils are few, and may not permit anything but the preparation of their usual dishes.

In parts of India, for instance, the rice ration was at one time twelve ounces a day. Shortage of rice forced the government to reduce the ration to six ounces a day. This meant 600-900 calories a day—almost starvation. To improve the situation, the government made a ration of wheat available in addition to the rice ration. But the people were not used to wheat, and very few bought it. The government then forced them to buy the wheat along with the rice. They bought the wheat and threw it away. Finally, the government sent out instructors to show them how to prepare simple dishes from wheat. This finally convinced them. Here, again, the real need was for more extension service.

In other cases, the need may actually be for improved salesmanship. I sometimes cannot help feeling, especially when some more advanced country wants to increase fish production, that expert advice by some of your excellent food marketing specialists might accomplish more than any actual assistance regarding production. For fish and other special foods, the situation is so often this: if a market can be created, increased production may come almost by itself.

Finally, all too often the difficulty is simply that the consumer cannot afford to buy the potential increase in food supplies. Basically, this is probably the most serious obstacle to any substantial increase in the world's food production.

This sad fact seems too often to be forgotten. For instance, two food specialists of high standing recently recommended that the food problems of both Greece and India should be solved by large scale canning. This seemed an obvious solution, because more fruits and vegetables were needed in the diet. They could be produced locally, but they were difficult to distribute in the fresh state due to slow transportation and a hot climate. Canning, then, seemed to be the answer.

It was pointed out by local experts that the population could not afford to use canned goods. The foreign experts argued that canned goods are cheaper than fresh. They actually are—in the U. S. A.—as you know. In more primitive countries, however, fresh fruits and vegetables are brought to the towns by the local farmer. He brings this merchandise in on his back, or on his mule's back, or on his wife's back, as the case may be. He does not charge anything for transportation; maybe he or she would like to go to the market anyway. They generally sell all they bring the same day, thus avoiding storage. This is cheap distribution. With this, canned goods cannot compete. Of course they could out of season when fresh products would have to be stored long, or brought long distances. But at that time the ordinary consumer just doesn't get them.

I have some figures which are extremely important in judging the possibilities for the retailing of food. They are the estimated per capita yearly income in various countries. In the first group comes the U. S.A. with a yearly per capita income of about fourteen hundred dollars. In the next group come countries like Canada, Switzerland, Australia, Great Britain and Norway, with a per capita income of seven hundred to eight hundred and fifty dollars. And in the third group come, for instance, Brazil, India, Pakistan, China, and Chile, with a yearly per capita income of twenty-five to seventy dollars.

I come from Denmark, a country of the second group, with an average per capita income of about half of the per capita income in the U. S. A. I can assure you that this difference in income gives entirely different perspectives. The conditions for increased canning or quick freezing industries, or for the development of sales of packaged foods are entirely different from the ones you have here.

In countries of the third group, with a per capita income of twenty-five dollars per year, the posibilities for any food processing at all are very limited, even if the increase in price will be very small. We have even experienced that the main obstacle to the use of modern milk pasteurization in one country was the very slight increase in production cost which this would cause. In countries with such low incomes, most food is produced domestically and when any economic or agricultural crisis occurs, starvation will be the result, because there just is not money enough to buy any emergency food supplies.

To help this situation these people must be put in a position where they can produce more food for themselves or else they must be put in a position to produce more goods to sell. Increased production may be either of food or of other goods, which they can sell in exchange for food. In any case, experts can help them increase their yield.

I think that when the world food crisis is considered, there is often a tendency to think too much in terms of food. The actual problem is just as much to put people in a position where they can afford to buy more food. Otherwise large funds would be needed to support relief food production. And where would such money come from? The needy countries do not have it. Otherwise they would have used this money for food already. So the production must be planned so that the product can be sold within the existing markets and at prices which cover the costs. This is obvious for a plan which calls for private investment. It is equally true for any government program—apart, of course, from an emergency program.

But now let us look at the purely technological part of the question. Here the problems should be much simpler. And I think they are. But they are by no means simple.

One thing which sounds very simple is just to establish what the real difficulty is. I, for one, have often felt that that is a serious problem. For instance, in one country I was met with the unanimous opinion by all the local fishery experts that the country needed more and bigger boats, and larger fishing equipment. Fish landings were low, so this seemed obvious. But I got up at four o'clock some mornings and went to the wholesale fish market. And there was actually a considerable carry-over of fish every day. And I found that during Holy week (this was in a Catholic country), consumption doubled. And then fish landings doubled. So the catching capacity was apparently there. The trouble, I thought, was an almost complete lack of a distribution system. In a city of more than a million people, there were only five fish stores. And in Copenhagen, a city of the same size, we have well over four hundred. And we think we have too few. Yes, agreed the experts, we need more competition among fish dealers, because they presently increase the price too much. Actually, the distributor's profits were lower than in any other country in that region. I felt that this probably was the very reason for the insufficient distribution. There simply was not profit enough to make any distribution system possible.

Thus my diagnosis led to a conclusion which was exactly the opposite of the one reached by the local experts. It doesn't matter who was right—the example still clearly illustrates the great difficulty in deciding what the real cause is.

Another difficulty: It is often tempting to recommend a little too quickly the adoption of the more advanced methods one knows from the technically more developed countries. And local experts are often very anxious to accept such methods. There is quite a natural tendency to feel that the higher developed economy of, for instance, the U. S. A., is due mainly to better manufacturing technics. Therefore, there is a general tendency to try to adopt those technics uncritically.

Let me again use the fisheries in Latin America as an example. Venezuela, for instance, obtained at one time a fishing boat of a type which gives excellent results in the Mediterranean. They copied this boat and tried to use the same fishing methods. But it proved entirely impractical, and none of these boats are in use for fishing in Venezuela now. And yet they are very effective in the Mediterranean.

Later on a development corporation there, the Pesquerias Caribe, brought some fishing boats down from the U. S. A. They selected some from the Mexican Gulf because the fisheries there are very similar to those in Venezuela. Nevertheless, the use of these boats was given up as entirely impractical. They could not compete with the type of boats already in use locally. From then on, the corporation concentrated on improvements of the local boats, financed the fitting out of these with insulated holds and engines, etc. This proved to be highly successful.

Therefore, wherever methods have to be improved, it is necessary to consider local conditions very carefully. It may even sometimes be advantageous to transplant primitive methods from one region of the world to another. For instance, when Argentina had a need for a long time emergency grain storage, she could not use any of the modern storage methods, but by an adaptation of the under-ground storage process which has been in use in Italy since Roman days, Argentina found a very satisfactory solution.

Similarly, the nutrition of many far Eastern countries, could undoubtedly be improved if soya-beans were used more extensively in the daily diet. But soya-beans are difficult to introduce. Bread baked from modern soya-bean flour has so far found little acceptance. But it might be that a product like the Javanese tempe, a fermented product made of cooked soya-beans, packed in banana leaves, could be introduced in other regions. Or, maybe, some of the many soya-bean dishes in use in China might be preferred. Or, new ways could be found to improve soya-bean flour.

By all this I certainly do not mean that there are no cases where more modern techniques can be put to use in the technically less advanced countries. The cases where this has been done profitably are too numerous to even mention. I would only like to point out that these methods, as well as any other one type of method, cannot be considered a cure-all. In each case the best procedure must be found with a mind open for all possibili-

ties, known as well as new, simple as well as refined, and antique as well as modern.

May I point to yet another problem? When experts come to technically under-developed countries, they are often much impressed with the lack of basic knowledge of resources, etc. Then some tend to conclude that, before anything can be done, a close study and appraisal of the full resources and possibilities must be made. This may look entirely justified. Yet I am sometimes a bit skeptical about it. I fear that it may lead to situations where minor projects and minor improvements are delayed seriously, or even stopped altogether. And this would be the opposite of helping development.

After all, were not most of the technically advanced countries developed without an over-all program? Just to illustrate my point, I may say that if, for instance, the Western U. S. A. had had to be developed according to an over-all program, we might still have experts and surveyors going around trying to find out whether the plains were any good, and whether California was worth developing.

One thing is true—if the U. S. A. had been developed in that way, we would have avoided the serious over-exploitation of resources which actually took place. But today we are talking about advice given by experts. I think that we, in that very fact, will be assured against mistakes in this respect.

Finally, it is extremely difficult to make such big over-all programs. Too many unknown factors are involved. Therefore, I think that, in this effort, it is better to proceed step by step, gradually gaining experience.

Thus, in most cases, I believe that it would be best to suggest that certain initial projects which appear to be safe and sound should be developed immediately; and a research or study program should be carried on simultaneously to ascertain the further possibilities.

All this has been about the assistance a food technologist can give by going to other countries, not only American food technologists, but food technologists of any country. In discussing this I have on purpose talked principally about the difficulties—at least, the difficulties as I have seen them. I have done this because it is so important that the difficulties be appreciated. And, when it comes to what actual technical advice can be given in each case, the individual expert, and not I, will be the person to give the suggestions.

There are, of course, still other fields where the food technologists can contribute. One important field is the development of entirely new foods. It is thus well known that yeast fermentation can give very high productions of highly nutritional material. The fact remains, however, that these products are difficult to use. You may know, for instance, that a large plant for the manufacture of food yeast was established recently in Jamaica. The plant is reported to have worked well technically, and the product was produced at sufficiently low cost. Nevertheless it had to be closed down because the product did not find consumer acceptance. More experience is needed, especially in the use of such yeasts.

Synthetic fats are also often acclaimed to represent a solution of the world's food problems. As you know, there was a considerable production of them in Germany during the war, but the production cost seemed to be about twice as high as the production cost for natural fats. Maybe new processes could be devised, and a cheaper synthetic fat manufactured.

There may be many other possibilities. Here again we must appeal to the food technologists of all countries to find them.

While speaking to this audience, I would like to say two things. They are small, but I would like to mention them because they embody something that can be done immediately.

Firstly, many countries are in severe need of exchange of publications. Some of them may not have much to offer in return. And some of it may be in a language which you cannot easily utilize. I also know that these large mailing lists are a nuisance to maintain. But I myself come from such a country, and I would like to assure you that the publications which you may be able to send research workers in foreign countries are highly used, and highly appreciated.

And another little thing. It is often very difficult for students from other countries to get money and foreign exchange to study in the U. S. A. To aid this, a trainee system has been set up. According to this, students from many foreign countries are permitted to take paid work in American industries,—so-called traineeships. It is not always easy to use such temporary help, but it may be an extremely good education for foreign students, and whenever it is possible, all of you can assist greatly by providing such opportunities for them.

In summary, the world is in desperate need for increased food supplies. The problems cannot be tackled as purely technical production problems. They must be seen in their complete relationship with industrial development, economic conditions, etc. But if they are attacked in this way, and with the same amount of skill and imagination with which the American food technologist has attacked the problems in his own country, I think that great achievements will be possible.

MOGENS JUL
Food and Agriculture Organization of the United Nations, Washington, D. C.

Physical, Organoleptic, and Histological Changes in Three Grades of Beef During Aging[a]

DOROTHY L. HARRISON,[b] BELLE LOWE, BUFORD R. McCLURG, AND P. S. SHEARER

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The effect of aging on cooking shrink, flavor, aroma, and histological changes in beef muscle is reported. The relationship of these changes to tenderness is discussed.

In this study some of the physical, organoleptic, pH, and histological changes occurring during aging and cooking of four muscles from four animals representing three grades of beef carcasses are reported. The muscles were chosen to represent varying degrees of tenderness within the carcass. In addition, the proportion of connective tissue to muscle, as determined by microscopic examination, is given. The chemical analyses of the elastin and the collagen content of these same muscles from one steer and the cow carcasses, as well as the changes, if any, in the amounts of these connective tissues brought about by aging and cooking the muscles are reported in a separate paper.

Lehmann *(4)* in his extensive study of the tenderness of muscles and its causes, found that aging increased the tenderness. Although the principal effect of aging on the organoleptic properties of beef is usually considered to be an increase in tenderness, the extent of this change does not always bear a direct relation to the length of storage. Hoagland, McBryde, and Powick *(3)* reported that beef stored two to four weeks was almost as tender as that stored a much longer time. Deatherage and Harsham *(1)* were puzzled when some steaks appeared less tender at certain stages of aging, whereas others progressively increased in tenderness throughout the aging period. In general, they found tenderness increased until 17 days; at 24 days there was no improvement or a slight drop in tenderness, and finally at 31 days there was some improvement beyond the 17 day tenderness measurement. Steiner *(9)* states that the rate at which ripening took place at a given temperature depended on sex, age, and other individual characteristics of the animals. Muscles of old animals aged more slowly than those of younger animals, and steer muscle ripened more slowly than cow muscle.

The relative tenderness of 25 muscles in the beef carcass has been reported by Ramsbottom, Strandine, and Koonz *(7)*. In a later study Ramsbottom and Strandine *(8)* compared the tenderness of 50 beef muscles. Tenderness was determined by shear force, judges' ratings, and a histological rating of the proportion of collagen and elastin to muscle tissue. Variation in tenderness occurred within the same muscle and between different muscles. Cooking increased the tenderness of some muscles, decreased the tenderness of others. Abundant connective tissue tended to increase the shear force readings. No relationship was obtained between the amount of fat within the muscle and the shear force of the raw or cooked muscle. Other factors also appeared to affect the tenderness of the muscle.

The principal effects of storage on the physical characteristics of beef, as reported by Hoagland, McBryde, and Powick *(3)* were loss of weight and hardening and darkening of the exposed muscular and fatty tissue.

The histological appearance of the muscle fibers varies with aging, Paul, Lowe, and McClurg *(6)*. Freshly killed beef muscle showed poorly differentiated fibers which were straight to slightly wavy. The fibers, in general, had distinct longitudinal striations. After 1 day of storage at 1.7° C. (35° F.) the fibers and cross striations were more distinct, the longitudinal ones less distinct. Contracture nodes, kinks, and waves increased in the fibers with longer aging. Kinks and waves tended to disappear after 4 to 9 days of storage. Disappearance of the cross striae in small, infrequent areas of the fibers was noted on the second day of storage. This disintegration of the cross striations increased in frequency and extent as the storage time increased.

Experimental Procedure

The beef was obtained from four animals. Animal I was a yearling steer, carcass grade Good; Animal II was also a yearling steer, but slightly older than animal I, carcass grade Good; Animal III was a large steer, about 14 months of age, carcass grade Commercial, which dressed to only 50 percent of his live weight; Animal IV was an eight-year-old dairy cow, carcass grade Cutter.

The muscles used were the paired psoas major, longissimus dorsi, semitendinosus, and semimembranosus. The muscles were dissected from the carcass 24 hours after the animal was slaughtered and most of the visible fat was removed. All longissimus dorsi muscles were divided into the rib and loin portions, after which each portion was cut into three roasts. Likewise each of the other muscles was divided into three roasts. This gave six roasts (three from the left and three from the right side) for each muscle. The roasts were placed unwrapped on enamel trays and stored at about 1.7° C. (35° F.).

The aging periods were 1, 2, 5, 10, 20, or 30 days. The statistical pattern for aging consisted of a five by

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[a] Part of a dissertation submitted by Dorothy L. Harrison to the faculty of Iowa State College in partial fulfillment of the requirements for the degree Doctor of Philosophy.

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[c] Approved for publication by the director of the Iowa Agricultural Experiment Station as Journal Paper J-1651, Project 934.

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six table for each carcass. One roast from each muscle was included in every aging period.

For cooking the roasts were placed on a rack in a kettle deep enough to cover them with lard which was held at 96°-98° C. (about 205°-208° F.). They were cooked to an internal temperature of 70° C. (185° F.). Data were recorded to determine: (1) percentage loss in weight during aging and cooking, (2) percentage shrink in length and the percentage change in thickness and width of roasts during cooking, (3) shear force of cooked roasts, (4) percentage of press fluid in cooked roasts, and (6) palatability scores for aroma, flavor, tenderness, and juiciness of cooked roasts.

Histological sections were made from samples of the cooked and uncooked roasts. The tissues were fixed in physiological salt solution plus 10 percent formalin. Longitudinal sections were cut 15 to 25 microns thick on a freezing microtome; stained with van Geisen's, Weigert's, and hematoxylin stains to differentiate the collagenous tissue, elastic tissue, and muscle fibers. They were mounted in glycerine jelly. After this treatment the elastic tissue was a blue black and the muscle fibers varied from greenish yellow to yellow orange. The uncooked collagenous tissue was bright pink or red. The cooked collagenous tissue, except in areas in which it was little changed by cooking, usually is not affected by van Geisen's stain. The arbitrary numerical evaluations of Ramsbottom, Strandine, and Koonz were used to compare the relative proportion of collagenous and elastic tissue in the muscles.

Results and Discussion

Since the roasts were stored unwrapped on enamel trays, evaporation of moisture caused loss of weight. The roasts from each muscle gradually decreased in weight as storage time increased (Table 1) until the average weight loss of the twenty roasts stored 30 days was 12.9 percent. The greatest weight loss occurred when the amount of surface area of the roast was large in proportion to the weight of the roasts.

TABLE 1

Average Weight Losses During Aging and Cooking and Shrink in Length of Roasts During Cooking

Changes in roasts	Days Aged					
	1	2	5	10	20	30
	%	%	%	%	%	%
Weight loss during aging, all roasts	00.0	1.0	1.8	3.3	9.9	12.9
Weight loss during cooking, all roasts	25.3	23.3	23.3	20.7	19.7	20.4
Shrink in length during cooking, all roasts	28.3	31.8	25.4	24.8	20.3	22.7
Roasts Animal I	15.1	23.4	18.2	16.1	15.8	15.9
Roasts Animal II	29.6	36.6	28.1	22.2	26.3	20.0
Roasts Animal III	31.8	30.1	22.6	27.9	23.8	24.0
Roasts Animal IV	36.9	36.8	32.8	33.0	15.2	31.0

The exposed surfaces of the roasts gradually became dark and dry. After 30 days of storage these surfaces were covered with a crust about one-fourth inch thick, and occasionally had small areas of mold on them. The surfaces of the beef next to the trays were moist and sticky from the fifth day through the thirtieth day of storage.

Cooking Data

The data (Table 1) indicate that, in general, the weight lost during cooking decreased slightly as the aging period increased. At each storage period roasts from the psoas major muscle lost less weight during cooking than roasts from other muscles.

The shrink in length of the roasts during cooking (Table 1) was not always linearly related to the time of aging the roasts before cooking, to the carcass grade, or to the collagen content of the muscles. The maximum shrink in length occurred with roasts aged the short periods, i.e., 1 and 2 days. With longer aging before cooking the shrink in length decreased, with the exception of the 30-day roasts, which was similar to that of the 20-day aged ones. The shrink in length (with the exception of the 20-day aged roasts) was always about twice as great for roasts from animal IV (Cutter grade) as for those from animal I (Good grade). The collagen content of the muscles of animal IV was approximately twice that in the muscles of animal I. The shrink for roasts from both animal II (Good grade) and animal III (Commercial grade) was about half way between that for roasts from animals I and IV. The shrink was always greatest for the psoas major muscles (which contained the least connective tissue) and approximately the same for the other muscles.

All but one of the 120 roasts decreased in width during cooking, and all but one roast increased in thickness during cooking. Because of the wide variation of these data within the roasts from a given muscle the percentage changes in width and thickness during cooking were not averaged.

Palatability Factors

There was little variation in the aroma and flavor scores for roasts aged 1 to 20 days, although the highest average scores were received by the roasts aged 10 days (Table 2). With longer than 20 days of storage, the aroma and flavor scores were definitely lowered. The 30-day aged roasts developed a "musty" or "off" odor and a "high" flavor. The aroma and flavor scores for roasts from animal I, however, increased gradually to

TABLE 2

Average Palatability Scores of Four Judges with Average Shear Force Values in Pounds and Press Fluid

Variables	Days aged					
	1	2	5	10	20	30
Palatability scores [4]						
Aroma, all roasts	8.3	7.9	8.0	8.2	7.8	6.8
Flavor, all roasts	7.5	7.5	7.6	7.9	7.3	6.9
Roasts Animal I	7.8	7.4	7.7	8.5	8.4	8.4
Roasts Animal II	8.2	8.1	7.9	8.7	7.5	7.0
Roasts Animal III	8.4	8.7	8.6	8.4	8.0	5.9
Roasts Animal IV	5.7	5.4	6.1	6.1	5.9	5.9
Juiciness, all roasts	7.0	7.4	7.0	7.3	6.8	6.2
Tenderness, all roasts	2.4	3.7	4.4	5.8	6.4	6.7
Roasts Animal I	4.2	5.6	6.3	6.7	7.6	7.4
Roasts Animal II	4.6	5.0	4.7	5.0	6.5	6.9
Roasts Animal III	1.0	2.8	4.1	6.8	7.4	7.4
Roasts Animal IV	0.0	0.1	2.5	3.4	3.9	5.2
Roasts Psoas major	8.2	8.6	8.6	9.5	9.1	8.9
Roasts Longissimus dorsi						
Ribs	1.8	2.5	4.9	5.7	6.1	7.6
Loin	—0.2	0.7	1.5	5.1	4.8	6.3
Roasts Semitendinosus	3.0	3.0	4.2	4.6	6.0	5.4
Roasts Semimembranosus	—0.5	2.0	2.8	4.1	5.9	5.8
Press fluid, all roasts, %	39.1	39.5	38.9	38.4	38.7	37.0
Shear force, all roasts, lbs.	30.4	28.8	26.7	25.3	24.0	21.5

[4] Maximum score for any factor, 10.

a maximum with 10 days aging and remained high for the 20- and 30-day stored roasts. Roasts from animal III, received the highest aroma and flavor scores for the short aging periods, i.e., 1, 2, and 5 days. When aroma and flavor scores were considered in connection with the carcass from which the roasts were obtained, those from animal IV were decidedly lower than those from the other three animals.

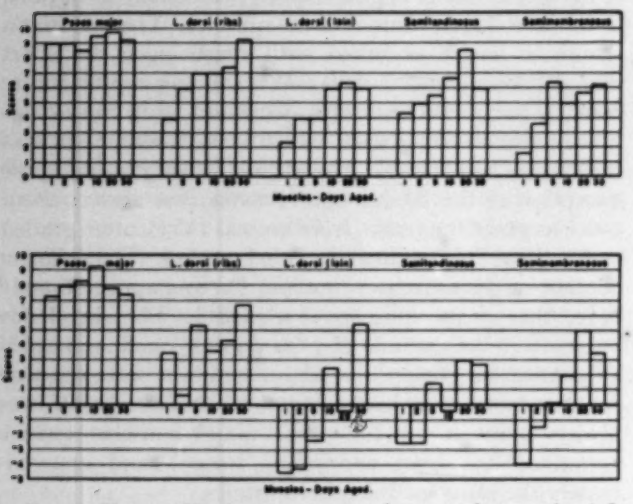

FIG. 1. Upper: Tenderness scores of roasts from animal I. Lower: Tenderness scores of roasts from animal IV.

The juiciness scores of the roasts remained about the same for the first 20 days of aging, then dropped slightly with 30 days of aging. By this time the evaporation of moisture from the unwrapped roasts during storage was great enough to reflect in the scores of the cooked roasts. The press fluid values followed the same pattern as the juiciness scores.

Analysis of variance of the tenderness scores showed that change in tenderness with aging, the variation among carcasses, and the variation among muscles were all great enough to be highly significant.

The tenderness scores for roasts from animals I, III, and IV (Table 2) show that the greatest increase in tenderness occurred during the first 10 days of storage. This is not true for roasts from animal II. Here the increase in tenderness was slow during the early part of storage, yet after 30 days of storage the tenderness of roasts from animal II was nearly comparable to tenderness of roasts from animals I and III. No explanation can be offered for roasts from animal II tenderizing more slowly than those from the other animals during the early period of aging, unless it was because of individual animal variation.

The average tenderness scores for all cooked roasts indicate a gradual increase in tenderness as the aging time progressed. However, when the scores for each muscle are considered separately (Table 2 and Fig. 1) the increase in tenderness with aging was not always linear. In this respect the results of this study are similar to those of Deatherage and Harsham *(1)*. Variation of tenderness within muscles may have affected the linearity of tenderness with aging to some extent. Ramsbottom, Strandine, and Koonz *(7)* as well as Hankins and Hiner *(2)* have reported that variation in tenderness occurs within certain muscles. Throughout this study the tenderness of the loin portion of the longissimus dorsi muscle has consistently varied from that of the rib portion. The effect of drying of the muscle during aging on the tenderness is not known. It is possible that it may have some effect. In eight out of twenty instances, the average tenderness scores for a given muscle were less after 30 days than after 20 days of storage. The eight roasts which had lower tenderness scores after 30 days of aging also had the highest weight losses during aging. It is of interest to note that roasts from animal III tenderized more rapidly with aging than those from animal IV. This is in accord with the results of Steiner *(9)* who observed that muscles from old animals aged more slowly than those from younger ones.

The negative scores (Table 2 and Fig. 1) are accounted for as follows: As an aid in estimating tenderness, each scorer counted the number of chews to masticate a standard sample to a determined end point. The score might be lowered 1 point for every 15 or 20 chews (determined in the preliminary tests). The number of chews for samples from animals I and II fell within the scores 0 to 10, with 10 designating the most tender sample. So many more chews were required to bring samples from animals III and IV to the determined end points, that negative scores were used to compare the scores with those from animals I and II.

The tenderness scores were related to the carcass grade. Roasts from the Good grade carcasses were the tenderest, those from the Commercial grade were intermediate, and those from the Cutter grade were the lowest. The tenderness scores for roasts from animal IV were very low and were undoubtedly influenced by the age of the animal as well as the carcass grade.

At each aging period the roasts from the cooked psoas major muscle were scored from 45 to 62 percent more tender than the roasts from any of the other muscles. This is in accord with the results of Ramsbottom, Strandine, and Koonz *(7)*. The tenderness of the other muscles in decreasing order follows: longissimus dorsi (ribs), semitendinosus, semimembranosus, and longissimus dorsi (loin).

The shear force (pounds to shear a 1-inch cylinder) values followed the same pattern as the tenderness scores. In general, the pounds for shearing decreased as the aging time increased, although tenderness of individual muscles was not always directly proportional to the storage time. The shear force values also ranked roasts from the different animals in the same order as the tenderness scores and the psoas major as the most tender muscle.

pH Measurements

Acidification of muscle occurred post mortem. The rate of this acidification varied among the carcasses, but was rapid during the first two hours after slaughter. Neck muscles were used for the pH values during the first 8 hours post mortem. These results are in line with those reported by Moran and Smith *(5)*. During storage the general pattern of the changes in pH of uncooked muscle was a slight drop following by a slow

rise. The difference in pH among muscles was exceedingly small, and the cooked roasts were slightly more alkaline than the uncooked roasts.

Histological Studies

The surface area is not alike in all portions of longitudinal sections. There may be much or little connective tissue, in strips or in irregular shapes. The fibers may be straight in some areas, waved in others. Different

FIG. 2. Upper: Fibers of the psoas major from animal IV (8-year-old cow), which throughout the 30 days of aging were more gnarled than those from the other animals. Lower: Fibers from the psoas major of animal I (yearling steer). Magnification x 190.

types of waves may be found. The diameter of the same and different fibers may vary. In some fibers or parts of fibers the longitudinal, in others the cross striae, or both types of striae may predominate. The cross striations may be wide or narrow and the spacing may be close or wide apart. Hence, descriptions are for the major areas of the sections being considered.

Microscopic examination of sections of cooked and uncooked roasts revealed certain characteristics peculiar to each muscle. In general, the differences between the cooked and raw sections were slight. The cooked sections were more opaque before staining and tended to have straighter fibers than the raw ones.

The psoas major, the most tender muscle studied, had the least connective tissue and also differed from the other muscles in absence of longitudinal striations, in fiber diameter, and in lack of strips of disintegration in the muscle fibers. The strips of connective tissue were usually short, rather narrow, and often contained one, two or more rows of fat cells. There was absence of longitudinal striations, even in the fibers from roasts aged short periods. The fibers were slender and varied very little in width. The cross striae were distinct and regularly spaced. The psoas major was tender, even after aging only 1 or 2 days, but maximum tenderness was reached after 10 days or longer aging. The observed disintegration of this muscle was increasing fragility. There were no long areas in the fibers in which the fiber striations had disappeared. There was some evidence that such disintegration had occurred, but the fiber membranes broke and the fibers fell apart in segments. The waves found in the psoas major were usually macroscopic in size, involving all or a large portion of the fibers in the section. The bends in the waves were usually "V" or "U" shaped.

The appearance of the psoas major fibers from the eight-year-old cow carcass differed from those of the other carcasses. The fibers and striae were more twisted and gnarled (Fig. 2) just as bark from older trees is more gnarled than that of younger trees. In addition, the fibers were less uniform in diameter, the cross striae less uniform in spacing.

The longissimus dorsi muscle fibers were characterized by the prominence of the longitudinal striations, variation in fiber width, the type of waves, and in the frequent disintegrated areas. The longitudinal striations predominated over most of the surface of the sections. There was a tendency for the longitudinal striae to become less distinct and the cross ones more distinct with aging, but longitudinal striae still characterized fibers from roasts aged 30 days. In some areas both striae were distinct, forming a checked pattern. The width of a fiber might vary considerably along its length or one fiber might be slender, its adjoining one wide. In the widened areas, the cross striae, if visible, were more closely spaced than in the narrow parts of the fibers. Wavy fibers were numerous, but the waves usually involved individual fibers. Many of the waves were alternating half circles, many were the z-z or accordion-like folds. Disintegration, involving a few striations, was found in a few sections from roasts aged 1 or 2 days. In general, there was not much disintegration until the roasts had been aged 5 days or longer. The disintegrated areas, increased in size and frequency with aging of the roasts. In most respects the rib and loin portions of the longissimus dorsi were similar. Disintegration, however, of the fiber striations usually appeared earlier and became extensive earlier in the rib than in the loin portion. This may have some connection with the loin portion being scored less tender than the rib portion. In general, disintegration of the fiber striations appeared later in fibers from animals III and IV than in those from animals I and II.

The semitendinosus sections were characterized by the large number of elastic fibers in the connective tissue. The fibers of this muscle had a sheen, almost an iridescence. The cross striae were predominant, although the longitudinal ones were found in many roasts. Disintegration of fiber striations appeared with 10 days or longer aging.

The semimembranosus fibers were characterized by the thin and narrow cross striations, which were closely spaced. The longitudinal striations, like the cross ones, tended to be narrow in width. They were usually more distinct than the cross ones in waved portions of the fibers. The waves were usually the same type found in the longissimus dorsi. Disintegration of the fiber striations was usually first observed in the 10-day aged roasts and was fairly extensive. Distintegration of the fibers increased with further aging.

The effect of aging. In general, as aging progressed beyond 2 days, there was a tendency for the fibers to

become straighter, with fewer waves, z-z contractions, twists, and kinks. These changes were not always linearly related to the time of aging.

The distinctive effect of aging was the loss of or disintegration of the protoplasm over an area of the fiber. There were two types of disintegration characteristic of aging; one was the increasing fragility of the fiber striations, found most frequently in the psoas major muscle. The other type of disintegration was the loss of fiber striations over a more extensive area. This disintegration might extend over a few or many fibers. Sometimes the sarcolemma remained intact, sometimes it broke. The disintegrated areas lost all evidence of either longitudinal or cross striae. The material within the sarcolemma had a granular appearance or was not visible with the staining technic used. This type of disintegration was common to all muscles studied, except the psoas major, after 10 days of aging.

In general, the histological changes, in the appearance of the muscle fibers with aging, were similar to those reported by Paul, Lowe, and McClurg *(6)*.

Amount of Collagen and Elastin in Muscles

The histological rating of the amount of collagen and elastin in the muscles is shown in Table 3. The ratings were the same for both cooked and uncooked tissues.

TABLE 3

Histological Rating of the Relative Amounts of Collagen (C) and Elastin (E) in Certain Muscles from Four Animals

Animal Collagen or elastin	I		II		III		IV	
	C	E	C	E	C	E	C	E
Muscle								
Psoas major	3	3	3	3	5	5	5	5
Longissimus dorsi (ribs)	5	3	5	3	7	5	7	5
Longissimus dorsi (loin)	5	3	5	3	7	5	7	5
Semitendinosus	5	7	5	7	7	7	7	7
Semimembranosus	5	3	5	3	7	5	7	5

1, none; 3, small; 5, medium; and 7, large amounts of collagen or elastin.

If the sections studied are representative of the entire muscle, such ratings can be reliable. The psoas major had the least connective tissue, the semitendinosus muscle the most. The muscles of animals I and II had less connective tissue than the muscles from animals III and IV. It is interesting that the histological rating agreed with the chemical determinations* (made on muscles of animals I and IV) with one exception. The chemical determinations showed that muscles of animal IV contained less elastin than those of animal I.

Summary

Four muscles, varying in tenderness, taken from carcasses of four animals, representing three grades (Good, Commercial, and Cutter) of beef were studied. The muscles were dissected from the carcasses 24 hours after the animal was slaughtered. The paired muscles (left and right) were cut into six roasts. One roast from each muscle was aged 1, 2, 5, 10, 20, or 30 days. The roasts were unwrapped and stored at 1.7° C. (35° F.). The most outstanding results were:

All roasts shrank in length during cooking. All but one of the 120 roasts decreased in width, and all but one increased in thickness. The shrink in length of the roasts from animal IV (8-year-old cow, Cutter grade) was approximately twice as great as those from animal I (yearling steer, Good grade).

Aroma and flavor scores varied only slightly among the muscles, but varied considerably among the animals, those from animal IV being much lower than those from the other animals. Variations in aroma and flavor scores with aging of the roasts were not as great as the variation among animals. Aroma and flavor scores reached maximum with 10 days of aging and decreased after 30 days aging.

When all roasts were considered, tenderness, whether determined by scores or shear force in pounds, increased with aging of the roasts, the greatest increase occurring in the first 10 days of aging. When individual muscles were considered, tenderness was not always linearly related to aging. Tenderness varied among the muscles, among the carcass grades, and among animals within a given carcass grade. The most tender roasts came from the best grade carcasses, the least tender from the poorest grade. In general, the tenderest roasts came from muscles and from animals having the least connective tissue.

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Determination of the Biological Value of Proteins With Tetrahymena Geleii H[a]

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Based on the response of the ciliated protozoan, Tetrahymena geleii H, to different dosages of unhydrolyzed proteins over varying times, the authors have proposed a microbiological method for the determination of the biological values of proteins in foods. The values obtained at 41 days incubation time are in reasonable accord with those determined by the nitrogen balance procedure.

The potentialities of *Tetrahymena geleii* H for the determination of the biological value of proteins, suggested in a preliminary report *(6)*, have been further investigated in the present studies. Biological values can be determined with this ciliated protozoan with greater speed, convenience and economy than with larger animals. Furthermore, errors due to biological variation are minimized, because of the large number of individuals and the aseptic conditions employed, and biological values can be expressed as a series of numbers representing volumes under planes relating dosage, time and response.

Experimental

The experimental techniques and the basal medium (amino acids omitted) were the same as those described previously *(15)*. Powdered samples of proteins or protein foods, containing from 5 to 50 g. of protein and equal amounts of nitrogen,[c] were weighed quantitatively and transferred to 250-ml. beakers. Approximately 100 ml. of distilled water and 20 ml. of 0.01 *N* NaOH were added and the mixture was allowed to stand at room temperature over night. The solutions or suspensions were diluted with approximatley 50 ml. of distilled water and the mixtures, brought to pH 7.0 with 0.01 *N* HCl, were made up to 500-ml. volume with distilled water in volumetric flasks. Aliquots of these solutions were diluted in volumetric flasks to the desired concentrations.

Samples were assayed in duplicate at nine levels ranging from 0.5 to 13.5 mg. of nitrogen per tube. Requisite volumes of sample solutions to give the desired final concentration of protein nitrogen, aliquots of distilled water sufficient to make the final volume of solution in each tube 10.0 ml., and one 4.0 ml. aliquot of basal medium[d] were transferred to each 19 X 150-mm. soft-glass test tube by means of a Brewer automatic pipetting machine. The tubes were plugged with cotton, placed in metal racks and autoclaved for 15 minutes at 15 lbs. pressure. After cooling the tubes, each tube was inoculated with 0.2 ml. of a washed suspension of *T. geleii* H cells.[e] The tubes, placed upright in racks, were incubated for times ranging from 6 to 41 days. Acid production was measured by electrometric titration as described by Rockland and Dunn *(14)*.

Proteins and protein foods whose biological values were determined by the authors' tetrahymena procedure are listed in Table 1. Acid production data obtained in a typical experiment on the response after 12 hours of incubation of *Tetrahymena geleii* H to the proteins given in Table 1 are shown in Table 2.

TABLE 1

Composition of Proteins and Protein Foods

Type	Moisture [l]	Ash [l]	Nitrogen [m]	Histidine [n]
	per cent	*per cent*	*per cent*	*per cent*
Casein [f]	6.21	0.55	14.49	2.75
Eggs, whole, spray dried [g]	3.65	4.3	7.35	1.09
Milk, skim, spray dried [h]	5.43	7.9	5.73	1.06
Soy flour, low fat [i]	6.55	5.2	7.74	1.23
Yeast-SB [j]	7.29	7.5	8.04	1.01
Wheat germ, defatted [k]	8.79	4.7	6.45	0.85
Wheat germ, defatted, toasted [k]	7.80	4.7	5.96	0.84

[f] Author's preparation *(5)*.
[g] Quartermaster Department, U. S. Army.
[h] Borden Company.
[i] Staley Manufacturing Company.
[j] Anheuser-Busch.
[k] VioBin Corporation.
[l] Method described by Dunn and Rockland *(7)*.
[m] Method of Miller and Houghton *(13)*.
[n] Determined with *L. mesenteroides* P-60 in HCl hydrolysates of proteins by method of Dunn et al *(5)*.

Biological Value Calculations

The titration values (Table 2) found at one incubation time (12 hrs.) for a protein sample at ten levels ranging from 0 to 13.5 mg. of nitrogen were plotted,[p]

[a] Paper 52. For Paper 51, see Rockland and Dunn *(15)*. This paper is part of a thesis submitted by Louis B. Rockland to the Graduate School of the University of California in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June 1948. This work was aided by grants from the National Institute of Health and the University of California. The authors are indebted to Dr. M. N. Camien, Mr. J. Lieberman, Mr. R. B. Merrifield and Dr. S. Shankman for advice and technical assistance.

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[c] Although amounts of proteins or foods containing equal amounts of nitrogen are usually used in determining biological values, this basis is not entirely satisfactory especially for yeast *(4,8)* and some other protein foods containing purines, pyrimidines and other types of nitrogeneous non-protein compounds. On the other hand, determinations of biological value based on moisture- and ash-free products may be more unsatisfactory owing to the presence of large amounts of carbohydrates and other impurities which are volatilized during the ashing process.

[d] Basal medium given in Table 1 of previous paper *(15)* made up to 400 ml.

[e] The inoculations were made with the aid of the pipetting machine using a sterile syringe assembly as described previously *(15)*. The inoculations were made as rapidly as possible without flaming the tubes to minimize contamination. Although contamination occurs occasionally it is readily detected by mold growth or inconsistent analytical results from replicate tubes.

[p] Millimeter graph paper, one centimeter equivalent to 0.5 ml. of 0.01 *N* NaOH and 0.338 mg. of nitrogen.

TABLE 2

Acid Production Data from a Typical Experiment on the Response of Tetrahymena Geleii H to Various Proteins [a]

Nitrogen level	Egg	Milk	Casein	Soy flour	Yeast	Wheat germ	Wheat germ toasted
mg.	*ml.*	*ml.*	*ml.*	*ml.*	*ml.*	*ml.*	*ml.*
0	0	0	0	0	0	0	0
0.68	—0.11	—0.05	—0.10	—0.50	0.10	—0.54	—0.09
1.35	1.45	3.12	1.97	—0.33	2.25	—0.02	—0.15
2.02	2.87	4.67	3.24	—0.15	3.91	0.73	—0.17
2.70	4.59	5.32	3.59	3.28	4.80	3.10	—0.17
3.37	6.02	5.96	3.81	4.19	5.46	4.44	—0.15
4.05	6.99	6.56	4.06	4.82	6.11	4.82	—0.12
5.40	7.61	7.62	4.72	5.33	7.36	5.46	—0.01
6.74	8.70	8.51	5.60	6.11	8.45	6.54	0.29
13.5	12.6	11.9	11.1	8.57	12.7	8.89	7.92

[a] Protein mixtures incubated at about 25° (room temperature) for 12 days.
Acid determined by electrometric titration to pH 7.0 with 0.01 *N* NaOH.
Acid values (ml.) corrected for acid produced in inoculated blanks at 12 days incubation time and in all uninoculated samples.

TABLE 3

Volumes Found for Protein Materials at Different Incubation Times [a]

Incubation time	Egg	Milk	Casein	Soy flour	Wheat germ	Wheat germ (toasted)	Yeast
days	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*
6	116	117	121	113	78	1	23
12	274	278	261	255	188	19	149
19	480	468	414	400	321	80	339
26	636	567	484	458	380	186	451
41	1126	906	717	696	606	408	805

[a] Volumes are expressed as cc. (cubic centimeters) equivalent to ml. of 0.01 *N* NaOH × mg. of nitrogen × days of time.

a smooth curve was drawn and the net positive area (positive area-negative area) bounded by the curve was determined with the aid of a planimeter. Other areas were determined similarly at incubation times up to 41

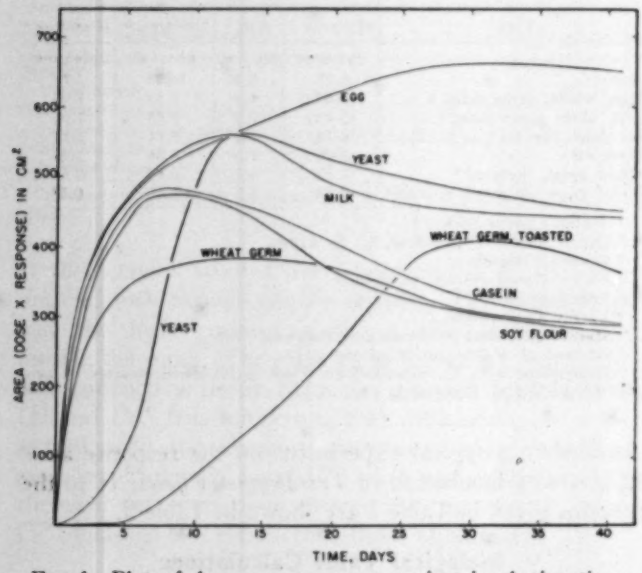

FIG. 1. Plot of dose-response areas against incubation time.

days, the areas at the various incubation times were plotted [q] and the area bounded by the resulting curve was determined. Area determined in this manner is volume, i.e., ml. of base x mg. of nitrogen x days of time.[r] Curves employed in calculating final areas (volumes) resulting from acid production at different levels of nitrogen over five periods of time for the seven protein materials listed in Table 1 are shown in Figure 1. The volumes found under these conditions are given in Table 3.

The biological values (relative volumes) of the protein materials at different incubation times relative to egg taken as 100 are shown in Figure 2.

Discussion

As may be noted from Table 4, the biological values found at 41 days incubation time by the authors' tetrahymena method are in reasonable agreement with those

TABLE 4

Biological Values of Protein Materials Determined by the Nitrogen Balance, the Tetrahymena and the Amino Acid Composition Methods

Protein material	Nitrogen balance [t]	Tetrahymena [u]	Amino acid composition	
			B and M [v]	Authors [w]
Egg	100	100	100	100
Milk	85	81	68	80
Casein	73	64	58	73
Soy flour	52-77	62	49	42
Yeast	60	72	45	45
Wheat germ	76	54	38	42
Wheat germ, toasted		36		42

[t] Quoted by Block and Mitchell *(3)*. Net utilization based on egg as 100.
[u] Authors' method. Values for 41 days incubation time.
[v] Block and Mitchell *(3)*.
[w] Calculated by Block and Mitchell's *(3)* method from amino acid composition given in Table 5.

determined by the nitrogen balance procedure. The biological values calculated from the amino acid composition of the protein materials investigated parallel those determined by the nitrogen balance and the tetrahymena methods. It has been pointed out previously *(3, 10, 11)* that amino acid composition is unsatisfac-

[q] Millimeter graph paper, one centimeter equivalent to 20 square centimeters and one day.

[r] The procedure outlined is essentially a double integration. The same final volumes result by plotting (a) ml. of acid against time in the first step and (b) the area of acid and time against mg. of nitrogen in the second step.

TABLE 5

Percentage of Essential Amino Acids in Protein Materials [x]

Amino acid	Egg	Milk	Casein	Soy flour	Yeast	Wheat germ	Wheat germ, toasted
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Histidine	2.4	3.0	3.1	2.5	2.0	2.1	2.3
Isoleucine	7.4	7.5	6.2	6.4	6.3	3.7	4.1
Leucine	9.2	10.2	9.7	7.7	7.5	6.0	5.9
Lysine	7.3	8.7	8.3	6.1	6.5	5.1	4.3
Methionine	2.9	2.3	3.0	1.2	1.3	1.2	1.3
Phenylalanine	4.8	5.1	6.0	5.0	3.8	2.5	3.0
Threonine	4.9 [y]	4.5 [y]	3.6	4.0 [y]	5.4	3.8 [y]	3.8 [aa]
Tryptophan	1.5 [y]	1.6 [y]	1.6 [z]	1.2 [y]	1.4	1.0 [y]	1.0 [aa]
Valine	7.0	7.4	7.0	5.3	5.8	4.4	4.4
Total	47.4	50.3	48.5	39.4	40.0	29.8	30.1 [bb]
Limiting total [cc]	47.4	46.4	45.9	39.1	39.5	29.8	30.1

[x] Determined by microbiological assay in authors' laboratory. Values calculated to 16 per cent nitrogen. Underlined values indicate limiting amino acids.
[y] Block and Mitchell *(9)*.
[z] Greenhut et al. *(10)*.
[aa] Value assumed to be same as for wheat germ.
[bb] Slightly higher values found for some amino acids may be due to lower nitrogen content (see Table 1). Mecham and Olcott *(11)* have shown that proteins subjected to dry-heat treatment lose significant amounts of nitrogen.
[cc] Total minus excess over that found in egg.

tory as the sole basis for determining biological values of proteins.

It is evident from the curves shown in Figure 2 that except for wheat germ the biological values determined by the present method vary markedly with incubation time. Casein and soy flour were as satisfactory as egg during the early stages of growth of *Tetrahymena* but

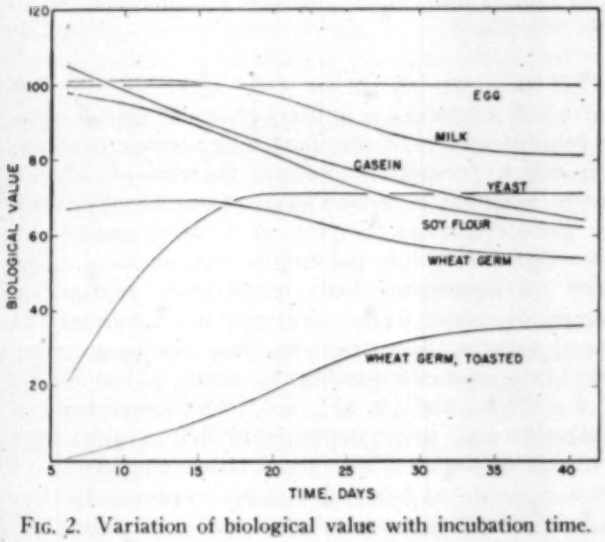

FIG. 2. Variation of biological value with incubation time.

both protein materials steadily decreased in effectiveness with increasing incubation times. The reverse of this behavior occurred with yeast and toasted wheat germ. The presence of purines and other potentially toxic substances may account for the relatively low biological values observed for yeast at short incubation times. That the nutritional value of proteins is decreased by heat treatment has been reported by Block et al. *(2)*, Evans and Butts *(8)*, Beuk et al. *(1)* and other workers cited by these authors.

Summary

A microbiological method based on the response of *Tetrahymena geleii* H to different dosages of unhydrolyzed proteins over varying times has been proposed for the determination of the biological values of proteins in foods. Biological values of egg, casein, milk, soy flour, yeast, wheat germ and toasted wheat germ determined by the authors' method have been compared to those found by the nitrogen balance and the amino acid composition procedures. The values obtained at relatively long incubation times are in close agreement with those determined by nitrogen balance. The biological values found varied markedly with the incubation time and the protein levels. These results indicate that a given protein may exhibit high or low biological value depending upon the age of the animal and its percentage in the diet.

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The Nutritive Value of Canned Foods[a]

XXVIII. Some Studies of Commercial Warehouse Temperatures with Reference to the Stability of Vitamins in Canned Foods

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Data from a two-year study of 79 warehouses are presented, and graphs are shown to indicate the relationship between the inside temperature of stored cans and temperatures inside and outside the warehouses. This study was supplementary to another on vitamin retentions during commercial and controlled storage.

Introduction

The necessity for proper storage conditions for commercially canned foods has been generally recognized for a number of years. At first, concern was primarily with external can rusting, internal can corrosion, and adverse effects of freezing warehouse temperatures on the quality of certain canned foods (Bigelow, *1*). Later studies demonstrated the beneficial effects of low temperature warehouse storage on the retention of canned food quality and extension of shelf-life through retardation of inside can corrosion (Kohman and Sanborn, *8, 9*).

Duing recent years, increasing interest has been manifest in the effects of storage temperatures on the retention of vitamins in canned and other types of preserved foods. It is beyond the scope of this paper to describe all the publications pertinent to this problem. However, a recent review covers rather completely the current status of knowledge on this subject (Feaster, Tompkins, and Pearce, *5*).

High Temperature Storage Studies. As elsewhere described, the current National Canners Association-Can Manufacturers Institute program was inaugurated in 1942 (Clifcorn, *3*; Pilcher and Clark, *11*). At that time, a major concern of military planning agencies was the possible effects of sustained high storage temperatures which prevailed in certain theaters of war on vitamin retention in canned foods. Consequently, work was sponsored under the N. C. A.-C. M. I. program in an attempt to establish quantitative data on some of the effects of continuous high temperature storage on vitamins in canned foods. Guerrant and associates *(6)* studied ascorbic acid, thiamine, and riboflavin retention in three canned foods stored continuously at 30° F., 42° F., 85° F., and 110° F., and found low retentions of ascorbic acid, in particular, after 270 or more days of storage at the maximum temperature employed.

Subsequently, cooperative studies between the National Canners Association, the American Can Company, the Continental Can Company, and the Quartermaster Food and Container Institute for the Armed Forces measured the effects of a maximum sustained storage temperature of 100° F. on vitamin retention in a variety of standard canned food commodities and canned ration items *(2)*. In general, low retentions were observed in the samples held at 100° F., particularly in the case of ascorbic acid, as noted by Guerrant. Since the above studies were begun, Dunlop *(4)* has reported the results of canned food storage tests conducted in the California desert and has suggested that for military planning purposes, the maximum temperature to be used in studies of storage effects on canned foods should be 90° F.

N. C. A.-C. M. I. Storage Studies. While high temperature storage tests such as those described above

[a] The investigation was part of the National Canners Association-Can Manufacturers Institute Nutrition Program.

may reflect some of the effects of extremely adverse military storage, more information was needed on the influence of usual peace-time storage conditions to which canned foods are subjected on vitamin retentions. Consequently, in 1944, additional experiments were undertaken at two universities to establish the effects on vitamin retention in canned foods of storage times and temperatures which closely approximated those prevailing in the warehousing and distribution of canned foods. The results of these studies have been reported by Moschette *(10)*, by Sheft, Griswold, Torlowsky, and Halliday *(13)*, and by Guerrant, et al. *(7)*.

As indicated by the above authors, the effects of sustained storage temperatures of 50° F., 65° F., and 80° F. were studied with respect to vitamin retentions in a number of canned fruit and vegetable products. Samples of tomatoes, orange juice, and peas, companion to those stored continuously at the three storage temperatures at the university laboratories were held at 9 commercial warehouses and cans forwarded periodically to the university laboratories for vitamin assay. In this manner, it was hoped that a correlation could be established between the effect of continuous storage at the three uniform temperatures and the effect of actual commercial warehousing on vitamin retention.

Studies on Warehouse Temperatures

The temperatures selected for sustained storage in the university studies were chosen by a special industry committe after consideration of all available information. The minimum sustained temperature, 50° F., was selected because storage temperatures of this order have been used in the quality control of certain canned foods and have proved economically feasible. The maximum sustained storage temperature used, 80° F., was chosen after consideration of temperature records for the continental United States for the period 1899-1938 (U. S. D. A. Year Book of Agriculture, 1941). These records indicated that in no part of the country did the average temperature for this forty-year period exceed 80° F.; in most localities the average temperature was below 80° F., even in typical summer months, such as July. The intermediate temperature employed, 65° F., was chosen as median to the minimum and maximum storage temperatures selected.

To test the validity of the selection of 80° F., as the maximum sustained storage temperature, arrangements were made to obtain records of actual temperatures experienced in 79 commercial warehouses distributed throughout the United States over a two-year period of observation. The first part of this paper presents data pertaining to four of the warehouses at which detailed temperature observations were made. The second part presents the findings at 75 other warehouses where only maximum and minimum temperatures were recorded.

PART I

Selection of Four Warehouses. Warehouses at New Orleans, Louisiana, and Tampa, Florida, were selected as representative of storage conditions in areas where high average temperatures prevail. A warehouse at Rochelle, Illinois, was chosen as typical of more favorable storage conditions in the North, where warehouses are heated during the winter. Yuba City, California, was selected as the site of the fourth warehouse since its prevailing temperature is intermediate.

At these four warehouses arrangements were made to collect detailed temperature data. A special wooden frame of 6-case capacity was placed in each warehouse to hold the samples and to prevent inadvertent shipment of the samples during the two-year period of the experiment. This frame was located near the floor in such a position that it was not immediately surrounded by other cases or subjected to abnormal heating or cooling effects. One can of peas in a full case (24 No. 2 cans) was fitted with one expansion bulb of a 2-pen recording thermometer and the inside temperature of the can was continuously recorded. The same instrument was used to continuously record the temperature of the air immediately surrounding the case. The daily maximum and minimum warehouse temperatures were obtained by means of maximum-minimum thermometers. The official United States Weather Bureau daily temperatures were also obtained for the period of the experiment.

The four warehouses varied with respect to size, capacity, and other structural details. The salient features in these respects are summarized in Table 1.

TABLE 1

Summary of Warehouse Features

Locality	Capacity No. 2 Cases thousand	Number of Stories	Construction	Roof	Ceiling Height feet	Forced Ventilation
Yuba City, Calif.	136	1	Corrugated Iron	T&G[a]	12	None
New Orleans, La.	125	3	Brick	Slate	15-20	None
Rochelle, Ill.	235	1	Brick and Tile	T&G[a]	20-24	None
Tampa, Fla.	95	1	Corrugated	T&G[a]	20	None

[a] Tar and Gravel.

TABLE 2

Yearly Average Temperatures

Locality	Year	Weather Bureau	Warehouse (Max. Min.)	Air Surrounding Case	Inside Can
		° F.	° F.	° F.	° F.
Yuba City	1945	61	69[b]	70[b]	69[b]
	1946	60	68[b]	67[b]	64[b]
Tampa	1945	73	76	76	74
	1946	75	76	76	75
New Orleans	1945	71	77	77	74
	1946	71	77	77	75
Rochelle	1945	49	62[b]	64[b]	63[b]
	1946	52	66[b]	68[b]	66[b]

[b] Warehouse heated during winter months.

Temperature Data. In Table 2 are presented the yearly average temperatures* observed at the four warehouses during 1945 and 1946, while the samples later analyzed for vitamin content at the universities were

*Average monthly temperatures of the daily maximum and minimum in each case are the arithmetic average of the mean of the daily maximum and minimum. Yearly average temperatures are the averages of the monthly averages.

in storage. The data include the yearly average temperatures of the Weather Bureau, of the participating warehouses as recorded on maximum-minimum thermometers, of the air immediately surrounding the case, and inside the cans. These figures show that all four of the yearly average temperatures were below 80° F. in each locality. They illustrate the very close relationship which exists between the warehouse temperature, the temperature of the air immediately surrounding the cases, and the temperature inside the cans, and show that in general these temperatures are somewhat higher than the temperature reported by the Weather Bureau.

In Figures 1, 2, 3, and 4 are presented graphically the monthly average temperatures recorded in the

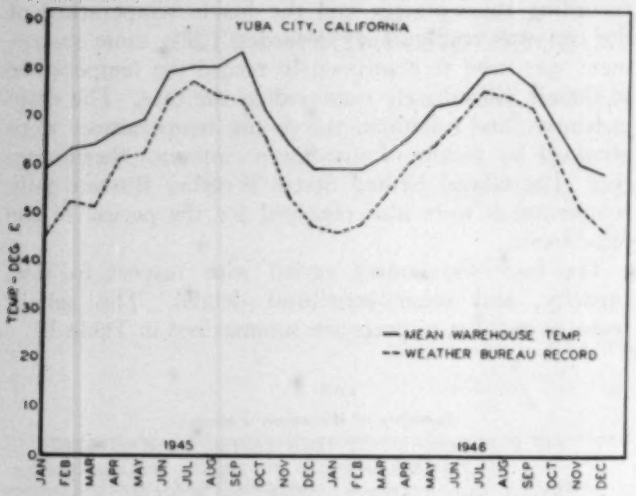

FIG. 1. Monthly average temperature—Yuba City, California.

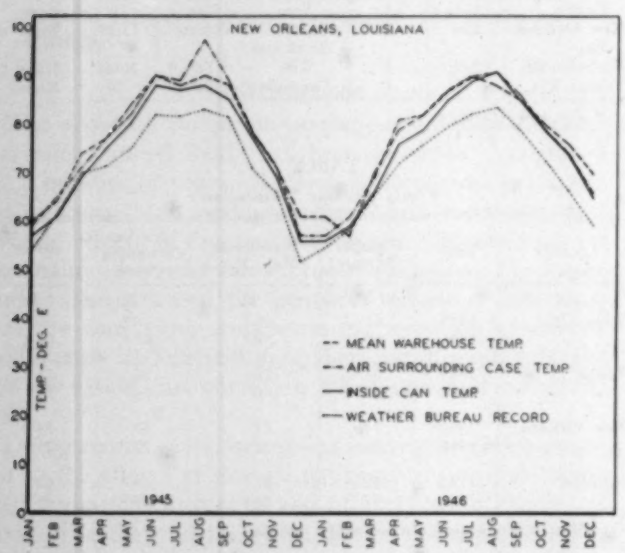

FIG. 2. Monthly average temperature—New Orleans, Louisiana.

respective localities during the test period. Inspection of the data indicates that the monthly average temperature remained below 80° F. more than half of the year. The data again indicate a close relationship between the warehouse temperatures, air-surrounding-case temperatures, and internal can temperatures. In general, all temperatures observed throughout the year within the warehouses were above those recorded by the official Weather Bureau.

Effect of Steady Outside Temperature. The complete daily temperature data are too voluminous to include in this report. However, representative data collected during weeks in which the temperature was steady or

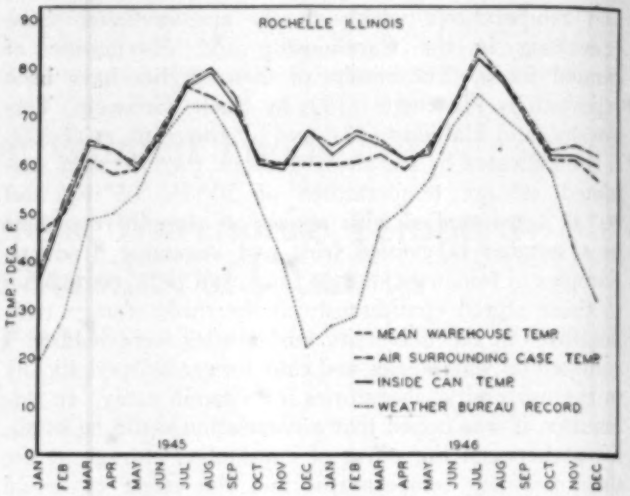

FIG. 3. Monthly average temperature—Rochelle, Illinois.

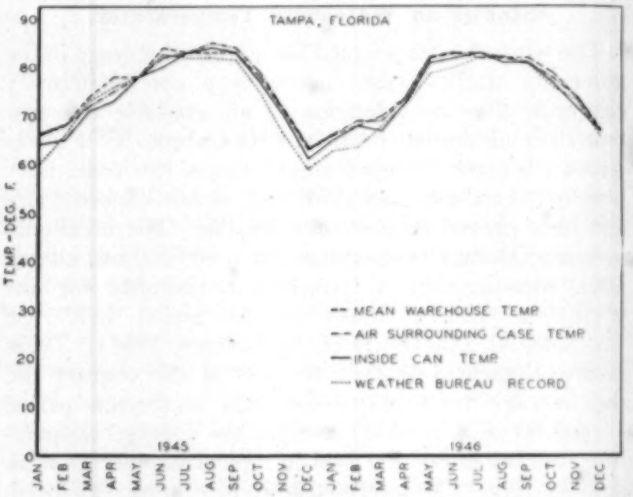

FIG. 4. Monthly average temperature—Tampa, Florida.

was rising are shown in Figures 5 and 6, respectively. Figure 5 records typical data obtained at Tampa, Florida, over a five-day period when the daily mean temperature was essentially constant and the difference between the daily maximum and minimum, as recorded at 3 P. M. and 3 A. M. varied between 14 and 17 degrees Fahrenheit. Inside the warehouse the temperature differed from the outside temperature in that the extent of the variation was reduced to about 5° F. Furthermore, variation of temperatures inside the can was limited to 1 to 2° F., suggesting considerable resistance to temperature change, evidently brought about by the insulating properties of the fiber case in which the can was contained and by the heat capacity of the filled cans.

Effect of Ascending Outside Temperature. In Figure 6 are shown data collected at Yuba City, California,

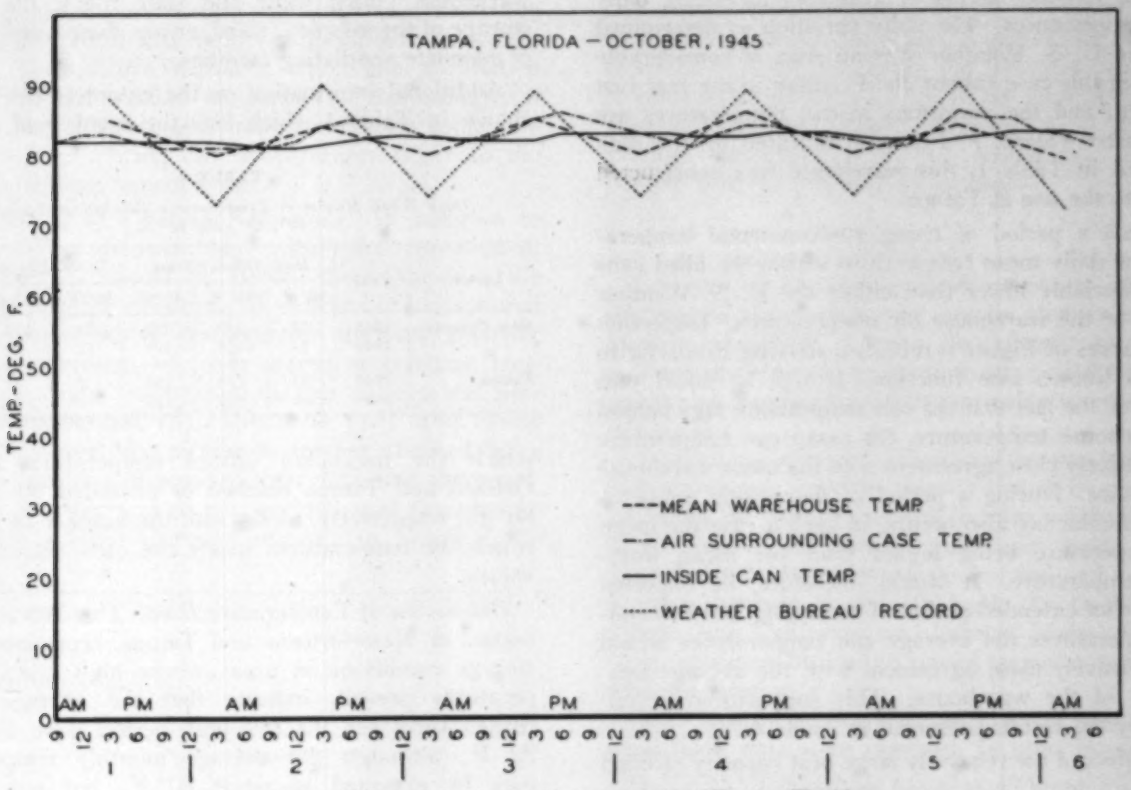
TAMPA, FLORIDA – OCTOBER, 1945
TEMP - DEG. F.
---MEAN WAREHOUSE TEMP.
-·-AIR SURROUNDING CASE TEMP.
——INSIDE CAN TEMP.
·····WEATHER BUREAU RECORD
AM PM AM PM AM PM AM PM AM PM AM
1 2 3 4 5 6

FIG. 5. Effect of steady outside temperature—Tampa, Florida.

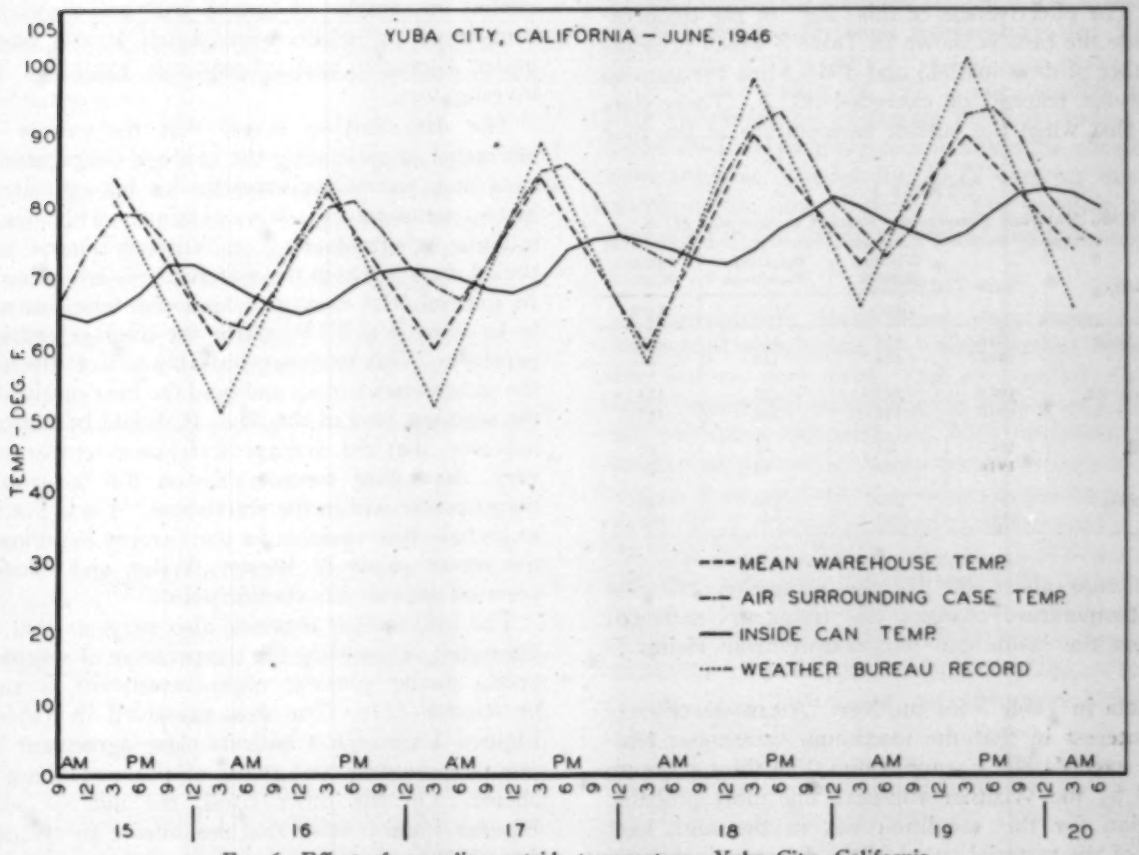
YUBA CITY, CALIFORNIA – JUNE, 1946
TEMP - DEG. F.
---MEAN WAREHOUSE TEMP.
-·-AIR SURROUNDING CASE TEMP.
——INSIDE CAN TEMP.
·····WEATHER BUREAU RECORD
AM PM AM PM AM PM AM PM AM PM AM
15 16 17 18 19 20

FIG. 6. Effect of ascending outside temperature—Yuba City, California.

during a five-day period of gradually ascending daily mean temperatures. The daily variation as determined from the U. S. Weather Bureau data is considerably greater in this case (about 36° F.) than in the case just described, and the variations in can temperatures are also greater (about 7° F.). As indicated by the data presented in Table 1, this warehouse was constructed similar to the one at Tampa.

In such a period of rising environmental temperatures, the daily mean temperature within the filled cans was appreciably lower than either the U. S. Weather Bureau or the warehouse air temperatures. Inspection of the curves of Figure 6 reveals a striking similarity to the well known sine function. It will be noted that except for the fact that the can tempearture lags behind the warehouse temperature, the mean can temperature is in relatively close agreement with the mean warehouse temperature. During a period of descending temperatures a similar lag also occurs, in such a case the mean can temperature being higher than the mean warehouse temperature. It would, therefore, be expected that over an extended period of ascending and descending temperatures the average can temperatures would be in relatively close agreement with the average temperature of the warehouse. This supposition is confirmed by the results presented in Table 2.

The effect of the relatively large heat capacity of filled cans in providing pronounced resistance to temperature change, is very significant. It means that although the temperature of the outside air or the the temperature inside the warehouses may reach high daily maxima, the temperatures inside the cans never fluctuate to that extent. The effectiveness of this "lag" of the temperature inside the cans is shown in Table 3 which presents the number of days in 1945 and 1946 when the various temperatures reached or exceeded 80° F. These data suggest that when the outside temperature at the four

TABLE 3

Days When Maximum Temperature Reached or Exceeded 80° F.

Locality	Year	Weather Bureau	Maximum Warehouse	Inside Can
		days	days	days
Yuba City, Calif.	1945	131	112	74
	1946	134	113	41
New Orleans, La.	1945	212	237	154
	1946	197	243	161
Rochelle, Ill.	1945	65	45	20
	1946	86	64	50
Tampa, Florida	1945	244	190	148
	1946	255	211	142

localities rose above 80° F., the protection afforded against temperature changes was frequently sufficient to prevent the inside can temperature from rising to 80° F.

The data in Table 3 for the New Orleans warehouse are of interest in that the maximum warehouse temperature exceeds 80° F. more often than the maximum recorded by the Weather Bureau. The most probable explanation for this condition lies in the high heat capacity of the materials used in the construction of the warehouse (brick walls and slate roof), the specific storage of the samples (third, or top, floor), and the lack of adequate ventilating facilities.

Additional information on the extent of the "lag" is shown in Table 4 which lists the number of days on

TABLE 4

Days When Maximum Temperatures Reached or Exceeded 90°, 85°, and 80° F.

Locality	Year	Max. Official Temp.			Temp. Inside the Cans		
		90° F.	85° F.	80° F.	90° F.	85° F.	80° F.
New Orleans	1945	77	128	212	23	117	154
	1946	51	127	197	32	97	161
Tampa	1945	83	172	244	0	27	148
	1946	81	183	255	0	11	142

which the maximum official temperature at New Orleans and Tampa reached or exceeded 90, 85, and 80° F., respectively, along with the number of days on which the temperatures inside the cans reached those values.

Discussion of Temperature Data. The data for warehouses at New Orleans and Tampa, representative of storage conditions in areas where high average temperatures prevail, indicate that the average yearly temperatures for the two-year period were less than 80° F., although the average monthly temperatures may be expected to reach 80° F., but not 90° F., between the months of May and September. Thus, the data appear to justify the maximum temperature of 80° F. used by Guerrant *(7)* and Moschette *(10)* as a constant storage temperature for vitamin retention studies on samples of canned fruit and vegetables, the counterpart of which were stored at the warehouses under discussion and subsequently examined by those investigators.

The data further reveal that the canner who is interested in estimating the average temperature inside cans in a warehouse may use for his estimates warehouse temperature data obtained with maximum-minimum thermometers, or Weather Bureau data in a period during which the warehouse is not being heated. In general, the average warehouse temperatures tend to be from 3 to 8° F. above the average outside temperatures. This tendency probably reflects the ability of the warehouses to trap and hold the heat received during the warmest part of the day. It should be remembered, however, that the average warehouse temperature will vary, depending considerably on the location of the thermometer within the warehouse. It was not possible to include this variable in the current experiment, but the recent paper of Riester, Wiles, and Coates *(12)* presents data on this specific point.

The information obtained also suggests that canners interested in lowering the temperature of stored canned goods should consider night ventilation as suggested by Riester *(12)*. The data presented in Table 2 and Figures 1 through 4 indicate close agreement between can temperatures and those of the warehouse atmospheres. On the other hand, the data presented in Figures 5 and 6 show that the outside air temperatures drop below the warehouse temperatures at night. In

warehouses not possessing a high degree of insulation it may be expected that night ventilation will reduce the average temperature within a warehouse so that it approaches the outside temperature. Accordingly, it appears that adequate and proper ventilation using cool night air might bring can temperatures closer to the Weather Bureau temperatures.

Correlation of Vitamin Retentions. In addition to the question of the maximum sustained temperature at which samples should be stored, there was also the matter of how the retentions of vitamins in foods stored in warehouses whose temperatures fluctuate compare with the retentions in foods stored at constant temperatures. Some information on this subject was presented by Guerrant *(7)*, Moschette *(10)*, and Shefft *(13)*. However, the picture is further clarified by a graphical analysis of some of their data, and the retentions of ascorbic acid in orange juice and thiamine in peas were selected as representative. In Figure 7 the

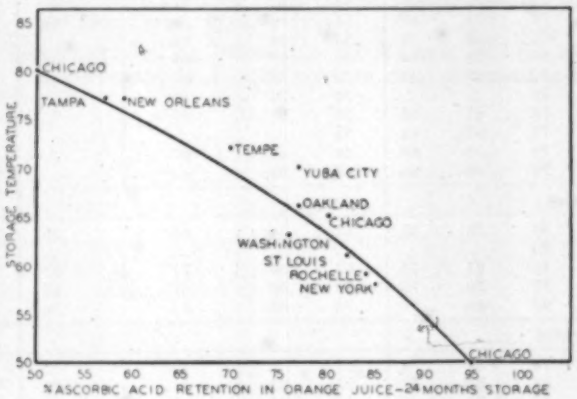

FIG. 7. Correlation of vitamin retentions at constant and fluctuating temperatures.

retention of ascorbic acid in orange juice after 24 months in storage is plotted against storage temperatures, both for the constant temperatures employed at the university and the average warehouse temperatures at nine different loctaions. Likewise, in Figure 8 thiamine retention in sweet peas after 24 months storage is plotted against the constant university temperatures and the average temperatures of the warehouses

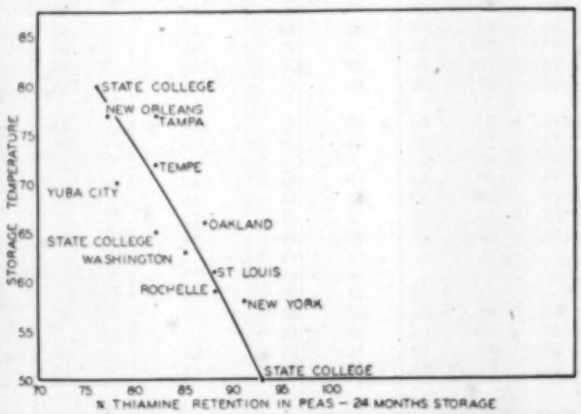

FIG. 8. Correlation of vitamin retentions at constant and fluctuating temperatures.

in the same nine locations. The graphical data on these two vitamins demonstrate that in general the retentions of vitamins at the fluctuating temperatures encountered in commercial warehouses are of the same order as the samples stored at constant temperatures if the yearly average temperatures of the warehouses are comparable with the constant temperatures.

PART II

Selection of 75 Additional Warehouses. While the selection of warehouses may not be ideal from a geographic standpoint, it must be pointed out that the shortage of personnel in the post-war period limited the number of warehouses which were able to cooperate in this survey.

A maximum-minimum thermometer was supplied to each warehouse with the request that it be placed five feet above the floor at a central location within the warehouse, away from outside walls and drafts. It was suggested that the thermometer be read and reset each morning between 8 and 10 A. M. In two instances (Santa Ana, California, and Payette, Idaho) the warehouse operators decided to record temperatures at more than one location.

Since most of the warehouses operated on a five-day-week basis, data were obtained, in most instances, for only five of the seven days in each week. Furthermore, in these cases the maximum and minimum read each Monday morning represented the maximum and minimum temperatures for the entire weekend.

Temperature Data. In Table 5 is presented the monthly average warehouse temperatures for 1946, the yearly average warehouse temperatures for 1946, and the average temperature for a two-year period starting in 1945 and ending in 1947. The monthly averages were calculated by averaging the daily means for the entire 28-31 days in the month when the complete data were available, and for the 20-22 working days of the month in the other instances. The monthly averages were used in calculating the yearly averages.

Summary

Comprehensive temperature data from (1) four commercial warehouses at which detailed temperature observations were made and (2) seventy-five additional commercial warehouses at which only maximum and minimum temperatures were recorded, indicate that the yearly average temperatures of cans in storage, even in areas of high prevailing temperatures, do not reach 80° F. Vitamin retention-temperature correlation data indicate that the vitamin retentions are essentially the same under constant and fluctuating storage temperatures. These data, therefore, would appear to justify the selection of 80° F. as the maximum sustained temperature to be used in studies of the effects upon vitamin retention of domestic warehousing and distribution of canned foods.

Acknowledgment

The authors wish to express their thanks to the Executive and Regional Committees for providing funds and for the active participation in the planning

TABLE 5

Average Warehouse Temperatures

Location	1946													2 Yr. Average
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average	
North Eastern Region														
Hartland, Maine	59	62	68	64	62	64	70	68	65	61	63	62	64	63
Portland, Maine	66	65	69	68	....	....	....	....	75	69	68	62	....	....
Gloucester, Mass.	67	66	74	73	75	76	76	72	72	74	69	70	72	73
Malden, Mass.	64	62	59	62	66	72	75	74	71	69	66	55	66	67
Mt. Morris, N. Y.	56	52	57	53	60	66	74	71	66	65	57	51	61	61
New York, N. Y.	32	33	43	45	57	66	71	69	71	67	57	48	55	56
South Eastern Region														
Houston, Del.	....	....	....	59	68	74	80	77	76	69	60	52	....	....
Wyoming, Del.	59	61	61	59	65	74	79	76	71	....	....	....	....	....
Washington, D. C.	75	74	74	72	73	78	81	79	76	76	75	75	76	70
Haines City, Fla.	65	66	72	76	80	82	82	82	83	78	77	70	76	75
Griffin, Ga.	48	52	63	71	77	85	85	86	79	69	....	....	....	....
Walkerton, Va.	44	44	57	60	69	79	80	78	77	69	62	52	64	64
North Central Region														
Blue Island, Ill.	73	72	76	74	76	79	88	78	76	74	76	72	76	....
De Kalb, Ill.	....	....	....	....	62	71	80	75	73	70	58	54	....	....
Eureka, Ill.	68	71	71	72	69	77	81	77	73	71	68	70	72	72
Fairmount, Ind.	57	55	67	69	66	73	81	78	77	70	55	60	67	66
Franklin, Ind.	42	43	55	59	63	76	82	76	73	67	56	50	62	....
Gwynneville, Ind.	61	62	67	66	68	78	83	77	70	66	63	61	68	....
Plymouth, Ind.	51	47	52	56	63	73	83	77	74	64	62	58	63	65
Portland, Ind.	51	53	59	....	63	73	79	77	73	68	48	46	....	....
Vincennes, Ind.	72	71	69	78	77	83	89	86	73	66	61	62	74	....
Marshalltown, Iowa	60	62	74	79	71	79	83	78	74	67	63	....	....	....
Lawrence, Kansas	69	....	....	67	69	82	86	81	76	69	66	67	....	....
Fremont, Mich.	57	57	62	65	64	70	76	75	71	70	68	63	67	66
Le Sueur, Minn.	58	60	64	69	69	75	80	78	73	67	65	65	69	68
Sleepy Eye, Minn.	55	54	58	60	61	71	78	76	68	59	52	54	62	....
St. Paul, Minn.	66	65	64	66	65	71	81	78	72	64	56	57	67	68
Wells, Minn.	54	51	55	57	58	72	77	72	67	59	51	57	61	....
Nebraska City, Neb.	68	67	68	72	70	78	82	80	....	....	74	72	....	....
Arlington, Wis.	59	59	61	62	64	66	77	77	65	68	58	58	65	....
Columbus, Wis.	49	48	57	54	61	66	....	72	67	63	55	....	....	....
Eau Claire, Wis.	60	60	65	68	68	70	75	73	70	69	66	65	67	....
Hartford, Wis.	58	59	64	61	62	69	....	74	70	66	60	59	....	....
South Central Region														
Blytheville, Ark.	47	50	61	69	73	82	88	84	78	68	61	54	68	66
Springdale, Ark.	40	47	59	66	60	75	83	83	....	....	....	....	....	....
Harvey, La.	56	61	67	74	79	82	85	86	82	75	67	60	73	72
St. Louis, Mo.	45	49	56	68	67	76	81	77	70	75	70	66	67	65
Austin, Texas	55	57	65	75	79	86	92	92	86	77	73	68	75	76
Rocky Mountain Region														
Phoenix, Arizona	....	60	....	80	84	90	92	92	89	71	61	....	....	....
Tempe, Arizona	57	59	67	75	80	83	85	88	83	73	67	62	73	73
Manzanola, Colo.	61	62	60	66	69	83	87	82	74	63	57	63	69	....
Franklin, Idaho	57	62	65	62	64	72	80	75	69	63	59	57	65	64
Payette, Idaho														
(Basement)	69	72	67	61	68	71	75	86	78	69	58	52	69	69
(First Floor)	64	66	63	65	70	79	87	85	76	68	54	48	69	69
(Outdoors)	31	36	49	58	65	70	80	77	66	54	42	39	56	55
Kaysville, Utah	62	65	63	53	59	68	81	85	72	58	54	57	65	66
Murray, Utah	65	67	66	66	65	73	80	78	75	67	72	70	70	70
Ogden, Utah	63	63	64	65	64	73	82	80	72	60	64	64	68	67
Smithfield, Utah	56	56	58	....	64	69	75	71	61	56	57	54	....	....
Spanish Fork, Utah	62	67	64	67	66	75	82	79	72	65	67	70	70	69
Pacific Coastal Region														
Burbank, Calif.	58	59	62	69	70	76	81	82	82	....	....	....	....	....
Emeryville, Calif.	56	57	60	64	68	72	76	76	76	72	62	57	66	67
Kingsburg, Calif.	60	62	60	68	70	74	80	83	76	69	62	62	69	69
Oakland, Calif.	62	62	62	63	66	70	75	76	74	70	61	62	67	67
Oakland, Calif.	59	58	62	64	66	71	73	71	73	75	67	62	67	67
Sacramento, Calif.	58	60	60	67	71	77	76	78	78	68	63	59	68	68
Sacramento, Calif.	55	56	64	71	76	80	84	81	77	69	63	59	70	69
Sacramento, Calif.	54	53	59	65	72	78	80	80	74	72	65	58	68	68
San Jose, Calif.	59	57	60	63	66	69	75	74	72	66	66	64	66	66
San Jose, Calif.	56	57	61	66	69	73	76	75	72	64	60	57	66	66
San Leandro, Calif.	59	59	61	64	65	70	72	66	67	66	60	61	65	65
Santa Ana, Calif.														
(Basement)	56	54	56	60	63	69	72	72	71	66	59	57	63	63
(First Floor)	55	54	57	62	64	70	73	73	73	65	58	56	63	64
Stockton, Calif.	47	50	59	67	72	78	84	84	81	....	....	....	....	....
Eugene, Oregon	56	54	56	58	63	67	74	73	70	63	59	56	62	....
Salem, Oregon	63	60	59	62	69	71	77	77	69	67	63	55	66	66
Mt. Vernon, Wash.	48	50	49	53	62	67	70	68	64	55	47	47	57	....
Olympia, Wash.	59	59	62	63	69	69	71	73	67	66	69	64	66	66
Seattle, Wash.	45	45	48	51	60	....	....	....	....	....	46	44	....	....
Seattle, Wash.	43	41	48	52	63	....	....	....	....	....	46	45	....	....
Seattle, Wash.	44	44	47	51	61	....	....	....	....	....	45	46	....	....
Toppenish, Wash.	62	61	58	60	70	75	81	81	69	61	62	61	67	67
Vancouver, Wash.	52	52	52	....	....	68	73	73	68	61	55	51	....	....
Waitsburg, Wash.	53	53	55	59	67	74	78	78	73	62	56	55	64	63
Yakima, Wash.	54	55	59	62	70	74	81	79	74	64	57	53	65	65
Hawaiian Islands														
Honolulu, T. H.	78	78	78	....	78	85	87	89	89	84	81	78	....	....
Honolulu, T. H.	73	74	76	76	79	81	82	83	81	80	76	73	78	78
Kahului, T. H.	76	77	76	76	79	81	81	82	81	81	79	76	79	79
Kahului, T. H.	76	77	78	77	80	81	82	83	84	82	79	77	80	79

and execution of this study. Acknowledgment is also due to the many canners who participated in collecting temperature data, without which this report would have been impossible.

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Chemical Evaluation of Odor Intensity[a, b]

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A chemical procedure, which was originally developed for the determination of spoilage in fish products, has been shown to be applicable to the estimation of the content of volatile substances in a wide variety of products. The method is based upon the determination of the volatile reducing substances by aspirating a known volume of purified air through the material into a standard solution of potassium permanganate in sodium hydroxide. The amount of reduction of the potasium permanganate is determined iodimetrically and is used as the index of the content of volatile material. The use of the procedure as a general method for evaluating the content of odorous constituents is also briefly discussed.

Introduction

Flavor is of concern to a wide variety of individuals and of particular importance to those in the food and related industries. Odor is an important component of the flavor complex and hence of the quality of a product.

A number of systems of odor classification and measurement have been proposed. Among these may be mentioned those of Crocker and Henderson *(2)*, Dyson *(4)*, Henning *(5)*, and of Zwaardemaker *(8)*. These have been reviewed, among others, by Crocker *(1)*, Crocker and Platt *(3)* and Moncrieff *(7)*. All of the systems elaborated to date have been ultimately based on subjective measurements with the resulting inherent limitations.

The lack of a reliable system of classifying and especially quantitatively measuring odors is generally recognized and the need for one readily admitted. At the present time the amount of odor is usually evaluated organoleptically. This is customarily carried out by trained and experienced individuals or groups of individuals. The scoring of the concentration or intensity of odors is thus only roughly quantitative, depending upon the degree of training, experience, and sensitivity or osphresiological acuity of the individual.

The need for a reliable and quantitative means of measuring odors was felt in a problem of particular interest to this laboratory, namely the determination of the state of freshness of raw and canned fish products. The procedure generally employed for this purpose is based on organoleptic judgment, involving a combination of physiological and psychological factors. The aim of the investigation was the development of an objective means of evaluating odors which would be accurate, reproducible and independent of the personal factors.

In the course of the investigation a chemical procedure was devised for the determination of the state of preservation of fish products which correlated very well with the organoleptic judgment. In fact, the method proved more sensitive than the senses, since gradation in samples, which were not easily evaluated organoleptically, could be readily measured chemically. During this study it became evident that the method which was developed primarily for fish spoilage evaluation might have a more general value. The official field of interest of the laboratory is fishery products. However, the possible applicability of the procedure to other phases of food technology involving products outside the scope of the laboratory's program was of sufficient interest to the author that the study herein reported was undertaken and carried out at various times during the course of a number of years. As a result of this study, the method could be regarded as a chemical means of evaluating odor intensity; in other words as a useful tool for odorimetry or osphresiometry.

Experimental

The details of the method have previously been described *(6)*. The principle of the procedure is the aspiration by a measured volume of purified air of the volatile constituents in a sample into a standard volume of alkaline potassium permanganate solution. The amount of reduction of the potassium permanganate solution, which is determined iodimetrically, is used as the index of the content of volatile substances in the sample.

An arrangement of the apparatus for a single determination is illustrated in Figure 1, showing the aeration flask with the air inlet tube closed at the bottom by a sintered glass plate, the two reaction vessels with their air inlet tubes also closed by sintered glass discs, the flowmeter to measure the volume of air and the air purification train consisting of three bottles containing normal potassium permanganate in 2 normal sodium

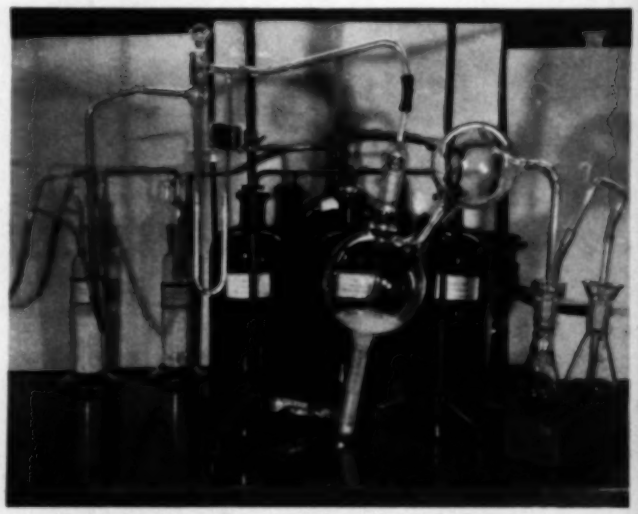

FIG. 1. A single unit apparatus for the determination of Volatile-Reducing Substances.

[a] Presented before the Annual Meeting of the Northern California Section of the Institute of Food Technologists, Berkeley, California, December 4, 1947.

[b] This study was carried out in the Fish Research Laboratory, which is supported by the Fish Packing Industry of California.

hydroxide. The use of silica gel to dry the clean air has since been discontinued and replaced by two empty bottles to serve as spray traps. A more portable two-unit apparatus is illustrated in Figure 2, from which the air purification train is omitted.

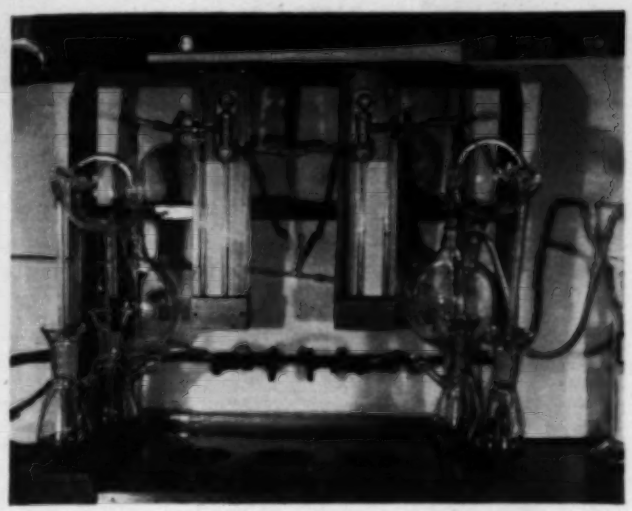

FIG. 2. A portable 2-unit apparatus for the determination of Volatile Reducing Substances.

The concentration of the potassium permanganate solution used varied from 0.10 N to 0.01 N depending upon the concentration of the volatile reducing or oxidizable substances in the sample. In all cases the solvent was 1 N solution of sodium hydroxide. The volume of air usually aspirated through a sample is two cubic feet and this is passed through in 40 minutes; that is at the rate of thre cubic feet per hour or 1.42 liters per minute.

Even though the above-described procedure (called volatile reducing substances or V. R. S. method) was primarily developed for determining the freshness of fishery products, its possible application to the estimation of volatile substances in other materials was an interesting extension of its scope. Accordingly, the volatile reducing substances (V. R. S.) in a number of commodities associated with distinct osmatic stimulation were determined with the above apparatus, which was designed for the particular experimental conditions met in testing fishery products.

In this presentation it is intended mainly to bring the V. R. S. procedure to the attention of those who may be interested in its use and who may find it applicable, perhaps with suitable modifications, to their particular problems. The data given below may be regarded as orientative or exploratory. No systematic study was made of the various products used and the results shown are illustrative of the possible applicability of the V. R. S. technic. Just as was done for fish products, a large number of representative samples of a uniform nature will have to be studied to establish possible ranges of values for any particular state of the commodity. Furthermore, such experimental conditions as volume of air and rate of aeration, amount of sample and type of aeration apparatus will have to be worked out for a particular type of material to facilitate the carrying out of the determination.

Results

In the following tables are shown representative results of V. R. S. determinations on a variety of odoriferous materials. In Table 1 are shown the values for V. R. S. in various freshly opened coffees.

TABLE 1

Volatile Reducing Substances (V. R. S.) in Various Brands of Freshly Opened Coffee

1 Gram of Coffee + 10 ml. H_2O aerated with 2 cubic feet air (56.8 Liters)

Sample	Microequivalents
A_1 in paper carton, CO_2 packed	110.2
A_2 Vac. pack glass jar	110.0
B_1 Vac. pack glass jar	119.2
C Vac. pack glass jar	99.0

The above coffee data were obtained by aerating 1 gram coffee mixed with 10 ml. of distilled water. The difference between the V. R. S. obtained by aerating the coffee from an aqueous suspension and that found by

TABLE 2

Effect of Aerating Dry or in Water on V. R. S. Recovery from Coffee

1 Gram Coffee aerated dry or in 10 ml. H_2O with 2 cubic feet of air

Sample	V. R. S.—Microequivalents	
	from water	dry
A old sample	68.5	77.7
B fresh sample	119.2	201.4
D old sample	24.1	99.6

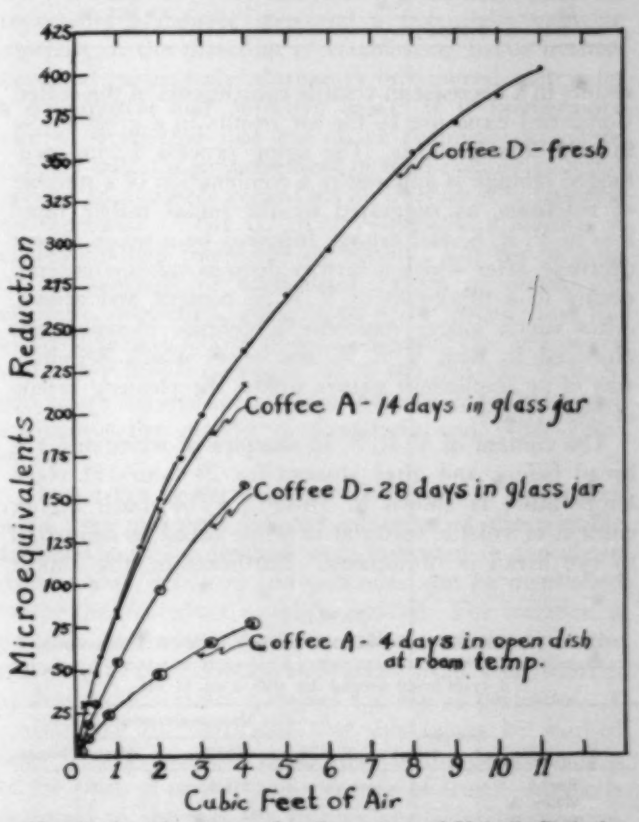
Microequivalents Reduction
Cubic Feet of Air
Coffee D - fresh
Coffee A - 14 days in glass jar
Coffee D - 28 days in glass jar
Coffee A - 4 days in open dish at room temp.

FIG. 3. Aeration curves for the content of Volatile Reducing Substances in various coffees after different storage periods.

aerating the sample dry is shown in Table 2. It is evident that some volatile material is held back by the water. The effect of storage in the container and exposure to air on the content of volatile reducing substances in various coffee samples is shown in Figure 3, and in Tables 3 and 4. Storage in the original container with periodic opening and exposure to air results in a decrease in volatile constituents of the coffee. Continued exposure to the air results in a greater loss in volatile substances. The aging process during prolonged storage is apparently a combination of a number of reactions, as suggested by the initial rather rapid loss in V. R. S. and aroma, followed by a much slower decrease, after which a further drop in volatile material occurs to a minimum of V. R. S. content and aroma. After much longer exposure a definite increase was observed in both V. R. S. and odor, which definitely was of an unpleasant nature unlike the pleasing aroma of fresh coffee.

TABLE 3

V. R. S. in Coffee C During Prolonged Storage in Open Vessel at room temperature

1 gram + 10 ml. H_2O aerated with 2 cubic feet air

Days Stored	Microequivalents Reduction	Description of Sample
0	75.3	Coffee 2 weeks in jar after opening—good coffee odor.
3	58.8	Sl. less coffee aroma, still good odor.
5	56.5	Sl. weaker aroma, still good odor.
8	54.9	About same odor.
14	50.5	Very little coffee aroma.
19	51.3	No coffee aroma, only roasted coffee odor.
38	40.4	Same.
48	32.6	Same.
74	54.0	Definite off odor. Not coffee-like.
83	63.8	Same—somewhat more marked

TABLE 4

Effect of Exposure to air at room temperature on Volatile Reducing Substances in Coffee A

1 gram + 10 ml. H_2O aerated with 2 cubic feet air

Days Stored	V. R. S. Microequivalents
0	110.2
2	75.9
25	65.8
52	34.3
7 in closed glass jar	104.0

The content of V. R. S. in samples of white and rye bread before and after storage for 24 hours at room temperature is shown in Table 5. The much higher content of volatile material in white bread as compared to rye bread is of interest. Furthermore, the almost complete loss in volatile reducing substances after a 24-hour exposure to air is also rather striking.

TABLE 5

V. R. S. in Bread Before and After Storage at Room Temperature

1 gram bread aerated dry with 2 cu. ft. air

Sample	Microequivalents V. R. S.	
	Fresh	After 24 hours
Rye	113.6	4.6
White A	179.2*	6.3
White B	274.8*	4.4

* 0.25 cu. ft. air used for these.

Some V. R. S. values for spices are shown in Table 6. Exposure to heat apparently resulted in a rapid loss in the more volatile constituents of the allspice sample, with a more gradual decrease of the less volatile components. The marked difference in V. R. S. content between yellow and red mustard seed parallels the organoleptic distinction.

TABLE 6

Volatile Reducing Substances in Spices

1 gram + 10 ml. H_2O aerated with 2 cubic feet air

Sample	V. R. S. Microequivalents	Hours Stored at 100° C.
Black pepper—5 months in container at room temperature	37.8	
Marjoram—6 months in container at room temperature	96.6	
Allspice—6 months in container at room temperature	490.4	0
	195.8	16
	172.4	41
	169.0	88
Mustard Seed, powdered		
Yellow	19.0	
Red	519.0	With 0.25 cu. ft. air
Red	2106.0	
Bay leaves	53.1	Aerated dry

In Table 7 are shown some determinations made for volatile reducing substances content on samples of onion, garlic and horse-radish. The volatile nature of the active principles is apparent.

TABLE 7

Volatile Reducing Substances in some Food Seasonings

All samples aerated with 2 cu. ft. of air

Type	Sample	V. R. S. Microequivalents
Onion	1 gram freshly sliced	37.6
	1 gram exposed cut surface	12.8
	1 gram slice after drying 19 hours at 50° C.	7.3
	5 ml. press juice	104.9
Garlic	1 gram clove stored room temperature for some weeks	49.5
Horse-radish	1 gram cut from fresh root	87.1

Various types of vinegars differ in their content of volatile impurities resulting from their source material, as shown in Table 8. The content of volatile aromatic components of vinegars, depends upon the source of the alcohol used for the acetic fermentation. The data of Table 8 suggest that the various kinds of vinegar may be distinguished by this method. This procedure may

TABLE 8

Volatile Reducing Substances in Various Types of Vinegar

5 ml. aerated with 0.2 cubic feet of air

Sample	V. R. S. Microequivalents
Wine	1206.2
Cider No. 1	144.6
Cider No. 2	130.8
Distilled white	67.0
5% Acetic Acid Solution	8.5

also be regarded as an extension of the permanganate oxidation number method for differentiating between vinegar and commercial acetic acid.

Some values for the volatile reducing substances in citrus peels and other fresh fruits are illustrated in Tables 9 and 10. Samples of prunes and raisins which had become dark and had developed a strong odor during storage were compared with samples having a good color and odor with the results shown in Table 11. The increase in content of V. R. S. in the dark colored samples with a strong odor over the control sample is evident.

TABLE 9

Volatile Reducing Substances in Fresh Citrus Peel

1 gram aerated with 2 cu. ft. of air

Variety	V. R. S. Microequivalents
Lemon	237.8
Tangerine	127.3
Orange	80.4

TABLE 10

Volatile Reducing Substances in Some Fresh Fruits

Variety	Sample	V. R. S. Microequivalents
Red grape	5 grapes, crushed	72.3
Large green grape	5 grapes, crushed	73.3
Winesap apple	1 gram pulp	18.5
Rome Beauty apple	1 gram pulp	21.0

TABLE 11

Volatile Reducing Substances in Dried Fruits After Storage Under Different Conditions

10 grams ground samples aerated with 2 cu. ft. of air

Variety	Sample	V. R. S. Microequivalents
Prunes	Good color and odor	44.4
	Off color and off odor	96.7
Raisins	Good color and odor	17.4
	Dark color and off odor	47.7

Some V. R. S. determinations were made on various species of odoriferous flowers to ascertain if their odors could be evaluated. The data for this series are shown in Table 12.

In Table 13 are shown data obtained for some vegetable and marine oils, showing their V. R. S. and peroxide content. The difference between the content of volatile reducing substances in the oils is quite marked and parallels their organoleptic judgments.

TABLE 12

Volatile Reducing Substances in Some Flowers

Variety	Sample	V. R. S. Microequivalents
Rose	1 gram of petals	65.0
Mock-orange blossoms	10 flowers	96.5
Acacia	1 gram flowers	49.5

TABLE 13

Volatile Reducing Substances in and Peroxide Numbers of Various Vegetable and Marine Oils

5 ml. aerated with 2 cubic feet of air

Variety	Sample	V. R. S. Microequivalents	Mols Peroxide per Kilogram
Corn	Fresh	33.0	0.032
Cottonseed	Very rancid	233.0	5.90
Soupfin liver	Weak "fishy" odor	46.1	0.60
Soupfin liver	Strong "fishy" odor	108.6	0.64

Discussion

One of the main observations which may be made from the above data is that the determination of the content of volatile reducing substances can be applied to a wide variety of odoriferous materials. Furthermore, by this procedure, a quantitative measure could be obtained of the changes in products resulting in a decrease or increase in the content of osphresiological constituents. Once the range of values for normal or acceptable samples has been established, then unknown samples can be quantitatively and objectively evaluated.

It is realized that the data herein presented are of a rather cursory nature. However, their presentation at this time is intended not as specific data for individual products but mainly to indicate some of the possible applications of the V. R. S. method. The problem of objectively and quantitatively evaluating flavor has occupied the attention of many individuals for a long time. The experts in flavor evaluation by organoleptic means, the coffee and tea tasters, spice judges and the like, require a personal aptitude and many years of practical experience in order to become adept and skilled in their art. After this long training period, their organoleptic judgments of flavor intensity are nevertheless based on personal preferences and interpretations and at best are comparative and largely qualitative in nature. It is therefore felt that the volatile reducing substances procedure previously described represents a definite step and a potentially valuable signpost in the direction of establishing flavor evaluation, and particularly odorimetry or osphresiometry, on a quantitative and objective basis. It is furthermore clearly recognized that the above chemical procedure permits only the measurement of total volatile material present in a sample regardless of whether it is pleasing or otherwise. That is, it is essentially a means of evaluating odor intensities chemically. For the judging of the pleasant or unpleasant nature of odors, for example, subjective organoleptic tests remain; and the aforementioned flavor judging experts can still serve their very useful purposes. It is felt that the V. R. S. procedure may prove a useful adjunct in judging and evaluating the quality of foodstuffs and other commodities.

Only a few of the many possible types of substances were used and only isolated instances of the possible application of the method were indicated in the above data. Other products and processes can be mentioned where the procedure could be applied. For instance, a possible extension of the aeration technique is the trapping of the odorous substances from such sources as flowers in suitable fixatives for use as perfumes. A preliminary run indicated that this might be worked out. Another possible application is the determination of the state of maturity or ripeness of fruits. Methods designed to increase the storage period of many commodities subject to loss in aroma could thus be evaluated

quantitatively. The field where flavor and its chief component, odor, are of interest and of concern is very broad. The V. R. S. procedure is brought to the attention of those who may find the chemical determination of volatile constituents of value in obtaining an accurate and numerically expressed measure of the odor component of the flavor complex.

Summary

A chemical determination of the content of volatile reducing substances in a sample by an aeration procedure is briefly described. By means of this method, the content of volatile reducing substances in spices, onion, garlic, horse-radish, various types of vinegar, fresh citrus peels and fruits, dried fruits, flowers and oils has been determined. The effect of storage and accelerated aging conditions on the content of volatile material in coffee, bread and spices has been described.

The possible application of the method to the field of flavor evaluation has been outlined and some examples have been pointed out.

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Rationalizing the Failure of a Quaternary Ammonium Compound[a] To Detect True Germicidal Activity in Sanitizing Glass Containers

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The recognition of germicidal activity of various quaternary ammonium compounds (Q. A. C.) in sanitization is well established; but reproducible results by workers in the same laboratory as well as in different laboratories at times is difficult because of the lack of standardization in technique. Alkyl dimethylbenzylammonium chloride (Roccal) as a member of this group demonstrated the following: (1) use of a neutralizer such as lecithin is essential to demonstrate optimum performance of Q. A. C.; (2) concentration of Q. A. C. per se within 100-400 p.p.m. is of minor importance; (3) time of contact with germicide (0, 5 and 10 minutes) is of minor importance; (4) ratio of 20/1 of asolectin to germicide is recommended for routine testing for bactericidal efficiency; (5) as a diluent a ratio of 10/1 of Tween 80 to asolectin is recommended. As a sanitizer interest lies primarily in percentage kill rather than complete kill.

It has been emphasized by Mueller *(9)* and generally agreed by others *(2, 8)* that results of laboratory tests on effectiveness of quaternary ammonium compounds as sanitizing agents may bear little relationship to their effectiveness in actual use. Any one method or methods to be finally adopted for use in commercial testing, however, must have the stamp of government approval. After 15 years since Domagk in 1935 stimulated research on quaternary ammonium compounds, agreement has not been reached on a single method that will accurately and repeatedly indicate true germicidal activity of quaternary ammonium compounds either for disinfection or for sanitization.

[a] Alkyl dimethylbenzylammonium chloride (Roccal).

Reports have been concerned with effects of organic matter *(3)*, neutralizers or inhibitors *(6, 10)*, details of methods *(13)*, quantitative versus qualitative testing *(4, 5, 8)*, solution versus glass slide technique *(2)*, ratio of inhibitors to quaternaries *(14)*, concentration of test organism *(7)*, effective concentration of quarternaries *(12)*, and other factors. For several years, the National Association of Insecticide and Disinfectant Manufacturers with cooperating laboratories and a Federal Agency have attempted to standardize a technique but to date there is inconclusive data whereby general agreement as to one or more suitable methods can be reached. At present two sub-groups, one on disinfectants and one on sanitizers are engaged in this problem. Interesting factors are being brought to light but they appear to be of theoretical interest and have little or no effect on practical application.

Our immediate interest lies with laboratory designation of effective quaternary ammonium compounds as sanitizer for glass containers that are manually cleaned, of such food items as fruit juice, syrups, etc. It is the practice of many such producers to handle returned soiled containers as follows: wash, rinse in clean water, and drain dry on a shelf until refilled. It is not surprising that the residual bacterial count is exceedingly high and that this contamination is reflected in the flora of the food product. Since certain quaternaries will sanitize effectively, it is desirable to record this in the laboratory. It should be possible to utilize a procedure similar to that used in Standard Methods for the Exami-

nation of Dairy Products for milk containers whereby washing, rinsing and sanitizing with a quaternary invariably leaves the container in a satisfactory condition in the laboratory and in the field. The coefficient of time versus concentration of germicide should be effective in sanitizing containers. If so, it becomes of interest to learn not only whether a sanitizer is effective in most instances (percentage of kill, not complete kill), but also to learn the relationship of concentration of inhibitor, concentration of germicide and time of holding resulting in a bacterial count of less than 100 colonies per ml. as determined by plating standard rinse water.

Experimental

To simulate field conditions whereby glass containers are washed, rinsed and sanitized manually, these procedures were followed in the laboratory:

1. Six oz. screw cap bottles, at least 15 bottles per trial, were washed in hot water containing a good detergent.
2. The bottles were rinsed by immersing in a pail of warm water.
3. Bottles with caps were then immersed in a solution containing a quaternary ammonium compound (Q. A.C.) at concentrations of 100 p.p.m., 200 p.p.m., and 400 p.p.m. and held for intervals of 0, 5, and 10 minutes.
4. The bottles were drained, capped and 50 ml. of the diluent used were added to each bottle, shaken 25 times, and 1 ml. aliquots plated in duplicate on tryptone glucose extract agar, colonies appearing within the 48 hours incubation at 37° C. were counted.

From preliminary results (Table 1) it was evident that distilled water, buffered or unbuffered, sodium thioglycollate and Letheen broth *(11)* were unsatisfactory as diluents, regardless of the concentration of the Q. A. C. or of the holding time. Fluctuation in individual plate counts suggested clumps of bacteria, or uneven dispersal of compound or both conditions.

The above was repeated using Tween 80 with asolectin as the diluent in various concentrations as well as variation in the ratio of asolectin to quaternary. It was evident that 0.2 percent asolectin in 2 percent Tween 80 was most satisfactory as a diluent, in that it permitted 100 p.p.m. of quaternary to be an efficient sanitizing compound. It was excellent in that more than 85 percent of the bottles in each trial showed a residual plate count of less than 100/ml. and that the percentage of kill per bottle was greater than 99.9 percent. An increase in holding time up to 10 minutes and increase in concentration to 400 p.p.m. showed inferior results and/or lack of uniformity in results described above.

An increase of Tween 80 to 3 percent or reduction to 1 percent to carry 0.2 percent asolectin resulted in poor to fair reduction in plate counts—lack of uniformity in plate counts, regardless of concentration of germicide.

To verify the observation that there was an optimum ratio of Tween 80 to Asolectin of 10:1 for best indication of performance of the quaternary regardless of concentration, this inhibitor as a diluent was applied in the following concentrations, while maintaining a ratio of 10/1 of Tween 80 to asolectin:

a) Tween 80 of 3 percent and asolectin, 0.3 percent, and maintaining a 20/1 ratio of asolectin to quaternary; b) 4 percent and 0.4 percent respectively; and c) 1 percent and 0.1 percent respectively.

A ratio of 10/1 of Tween 80 to asolectin and a ratio of 20/1 of asolectin to quaternary gave indications of uniform sanitizing effectiveness—50 to 200 p.p.m. The above results are summarized in Table 2.

TABLE 1

Effect of a Neutralizer on Ability of a Quaternary Ammonium Compound to Demonstrate Sanitization

Neutralizer	Holding Time in Q. A. C. in minutes	Concentration of Q. A. C. in p.p.m.	Results [c]
Tween 80 (3%) + Asolectin (.2%)	0 [b]	100	Good
	5	100	Poor
	10	100	Poor
	0	200	Good
	5	200	Poor
	10	200	Poor
	0	400	Poor
	5	400	Poor
	10	400	Poor
Letheen Broth	0	100	Fair
	5	100	Poor
	10	100	Poor
	0	200	Fair
	5	200	Fair
	10	200	Fair
	0	400	Good
	5	400	Fair
	10	400	Poor
Sodium Thioglycolate Broth	0	100	Fair
	5	100	Poor
	10	100	Poor
	0	200	Fair
	5	200	Poor
	10	200	Poor
	0	400	Good
	5	400	Fair
	10	400	Poor
Buffered Distilled Water	0	100	Poor
	5	100	Poor
	10	100	Fair
	0	200	Poor
	5	200	Fair
	10	200	Poor
	0	400	Excellent
	5	400	Fair
	10	400	Fair

[b] 0 minutes—5-10 seconds.

[c] Excellent—Better than 85% of samples showed plate counts of <100/ml.
Good—Better than 70% of samples showed plate counts of <100/ml.
Fair—Better than 50% of samples showed plate counts of <100/ml.
Poor—Less than 50% of samples showed plate counts of <100/ml.

TABLE 2

Relationship of Ratio of Tween 80/Asolectin as Neutralizer and Asolectin/Quaternary Ammonium Compounds on Efficiency of Quaternary Ammonium Compounds as Sanitizer

Quaternary Ammonium Compounds in p.p.m.	Tween 80	Asolectin	Ratio of Tween 80/ asolectin	Ratio of aso/Q. A. C.	Effect of Q. A. C. as sanitizer [d]
100	3%	.2%	15/1	20/1	Fair
200				10/1	Poor
400				5/1	Poor
100	1%	.2%	5/1	20/1	Fair
200				10/1	Poor
400				5/1	Poor
100	2%	.2%	10/1	20/1	Excellent
200				10/1	Poor
400				5/1	Poor
50	1%	.1%	10/1	20/1	Excellent
150	3%	.3%	10/1	20/1	Excellent
200	4%	.4%	10/1	20/1	Excellent

[d] Excellent—Better than 85% of samples showed plate counts of <100/ml.
Good—Better than 70% of samples showed plate counts of <100/ml.
Fair—Better than 50% of samples showed plate counts of <100/ml.
Poor—Less than 50% of samples showed plate counts of <100/ml.

Discussion

Alkyl dimethylbenzylammonium chloride was an effective sanitizer—100 p.p.m. giving excellent reduction in counts. The efficacy of this quaternary ammonium compound as well as others has been claimed and demonstrated many times, although there still remains a healthy skepticism because of the difficulties in demonstrating uniformity in laboratory results.

Lecithin (asolectin in Tween 80) provided an excellent neutralizer used as a diluent in these sanitizing experiments. There are limitations to this phosphatide, however, as emphasized by Weber and Black *(14)*. Recent literature shows considerable variation in the recommended ratio of Tween 80 to asolectin. In this series, it was found that a 10/1 ratio provided excellent results as long as sufficient quaternary ammonium compound was available. Due to the physical properties of lecithin (asolectin in Tween 80), there are definite limits of possible concentration of this inhibitor. There is an optimum ratio of asolectin to its solvent Tween 80. Too much aso./Tween 80 prevents good solvency and medium becomes oily; too little aso./Tween 80 results in ineffectiveness. In both instances the prevention or reduction of bacteriostasis by a neutralizer becomes less effective or ineffective.

Even if it were granted that lecithin in an optimum ratio of asolectin to quaternary would prevent bacteriostatic action, as a sanitizer the interest is in percentage kill rather than complete kill.

Although Weber and Black *(14)* claimed that no one single inhibitor would protect all types of bacteria encountered under practical conditions, the reverse appears to be true. For pure cultures of test organism, a single inhibitor may fail to protect all; however, under practical procedures as applied in this series where there usually are many varieties of bacteria on soiled glassware a ratio of 10/1 of Tween 80 to asolectin and a ratio of 20/1 of asolectin to Q. A. C. is effective with concentrations of Q. A. C. of from 50-400 p.p.m.

Vigorous agitation with the diluent just prior to plating seems to remove the necessity of the inclusion of the inhibitor in the plating media.

A great deal of controversy is based on the failure to recognize that a Q. A. C. used as a sanitizer need not demonstrate complete freedom from bacteriostasis. Since the factors involved permitting the effect of bacteriostasis are so complex and certainly at times, by chance, there remains one solution—"in vivo" testing.

Summary

Demonstrating sanitizing effect of alkyl dimethylbenzylammonium chloride in the laboratory is a relatively easy problem if certain conditions are met. The use of a neutralizer such as lecithin in a ratio of 10/1 of Tween 80 to asolectin, and a ratio of 20/1 of asolectin to quaternary ammonium compound insures uniform results irrespective of concentration of quaternary ammonium compound from 100-400 p.p.m. and holding time (0, 5, and 10 minutes).

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The Effect of Desiccation on Frozen Vegetables[a]

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The possible effects of extreme desiccation, amounting to as much as one-fifth of the weight of frozen green beans, corn, spinach, and peas, have been studied over a storage period of one year at 0° F. Changes in the appearance of the frozen product were evident after desiccation, but the cooked vegetables were similar regardless of prior moisture loss. No loss in palatability (texture, flavor, surface appearance, color) or nutritive value (ascorbic acid, carotene) resulted from desiccation.

The necessity of preventing drying or desiccation of frozen foods is constantly stressed. "Freezer-burn" on meat, fish, and fowl is the undesirable result of surface drying of these products in the frozen state. The need for preventing a partial desiccation of frozen vegetables has never been conclusively demonstrated. Since frozen vegetables are boiled in water as preparation for consumption, they have an opportunity to rehydrate.

Rabak *(6)* studied the effects of desiccation of frozen peas after twenty months' storage at 0° and 15° F. (—17.8° and —9.4° C.). He reported that moisture losses exceeding five percent impaired the color of the cooked product and resulted in a toughening of both skin and cotyledon. High moisture losses during storage were associated with impaired flavor and ascorbic acid destruction especially in those packages which had been stored at 15° F. The ascorbic acid content of peas stored at 0° F. was higher than that of peas stored at 15° F., but it was not influenced by desiccation during storage.

Woodroof *(8)* reported that string beans lost 12.8 to 36.0 percent of their weight when stored a year. The weight of the desiccated beans after soaking for eight hours in water was 90 to 97 percent of the original weight. Although the statement was made that flavors were lost, apparently none of the desiccated products were cooked and scored for palatability changes. Nor was the ascorbic acid content of the fresh and desiccated products determined.

Studies on the freeze-drying of food products indicate that desiccation *per se* may not be deleterious *(2)*. Even partial dehydration followed by freezing of the food does not seriously affect the quality *(1)*. However, structure changes over a period of time may lower the rehydration capacity during prolonged storage. Moreover, the porous nature of the desiccated tissue offers a greater exposure to aerobic oxidation. It is also possible that flavors may be lost by evaporation. To study the importance of these factors, the present study was undertaken.

Various possible effects of desiccation of four frozen vegetables have been evaluated in terms of time versus moisture-loss relationships, and the results are reported in this paper.

Experimental

The four vegetables selected for this desiccation study included green beans,[d] corn,[e] spinach,[f] and peas.[g] Commercially frozen vegetables were purchased in quantities large enough to permit preparation of all samples from single lots. Loose pack products, with the exception of spinach, were selected to facilitate desiccation prior to packaging and storage.

The control samples were prepared by repacking 250 gram portions of the vegetables, as received, in foil-lined bags[h] previously shown to be completely moisture-vaporproof.

The desiccated samples were prepared by spreading the frozen vegetables in thin layers on tared trays in a freezer known to have a low relative humidity. The vegetables were stirred frequently to permit uniform drying. When the vegetables had lost 10 percent of their initial weight, portions of the desiccated products were packaged in the foil-lined bags. Twelve packages, each containing 225 grams, were prepared. After the vegetables had lost 20 percent of their initial weight, twelve packages, each containing 200 grams, were prepared. When these three grades of samples were ready for storage, a fourth set of twelve packages at the original moisture levels was prepared. The packaging material used for this set was a heavy vegetable parchment,[i] which by previous tests was shown to have a MVTR high enough to permit approximately 10 to 20 percent moisture-vapor loss from the vegetables after twelve months' storage at 0° F. (—17.8°C.).

The preparation of the spinach samples was slightly different. Since the product used was a solid pack, the packages were partially thawed and the spinach was torn apart and spread in thin layers in a freezer at —40° F. (—40° C.). After the spinach was refrozen, it was transferred to tared trays in the 0° F. freezer,

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[d] Green beans, 2 lb. package. The Winter Garden Co., Knoxville, Tenn.

[e] Corn, 2½ lb. package. Curtice Bros. Co., Rochester, N. Y.

[f] Spinach, 12 oz. pkg. Birdseye-Snider Co., New York, N. Y.

[g] Peas, 12 oz. pkg. Olney and Carpenter Co., Wolcott, N. Y.

[h] Reynolds Metals Co., Reynolds Metals Bldg., Richmond 19, Va.

[i] "Special treated Patapar," Paterson Parchment Paper Co., Bristol, Pa.

[j] Hyflo-Supercel. Johns-Manville Corp., Buffalo, N. Y.

desiccated, and handled in the same manner as the other vegetables.

The initial analyses were carried out on representative portions of the vegetables which had not been desiccated, and on those which had lost 10 and 20 percent of their weight by desiccation. The packaged vegetables were stored at 0° F. After three, six, nine, and twelve month storage periods, three samples of each desiccation class were withdrawn for analysis.

The packages were weighed before and after storage to the nearest one-tenth gram in a 0° F. room to prevent moisture condensation on the package surface. All samplings were made on an equivalent (original) weight basis, thus correcting for desiccation at the time of each analysis. All results are reported on the basis of the original fresh weight.

Analytical Methods and Observations

Rehydration Capacity. The rehydration capacity of the vegetables was determined initially and at the end of each storage period. The weight of raw vegetable cooked was 100 grams or its equivalent, i.e., 90 grams of the 10 percent, or 80 grams of the 20 percent desiccated vegetables. The weight difference was made up by increasing the volume of water added. The cooked, drained vegetable was weighed and to that weight was added the weight of solids in the cooking water. This total represented the capacity of the vegetables to resorb water.

Palatability Scores. The cooked vegetables were scored by a group of five judges on the basis of appearance, texture, flavor, and general acceptability. The points scored for these various factors were weighted to give the following percentages of the total score of 100: surface appearance, 6; color, 12; texture, 24; flavor, 42; and general acceptability, 16. The samples for cooking were composites taken from the three packages of each desiccation treatment.

Ascorbic Acid. The ascorbic acid content of the raw vegetables was determined by the indophenol-xylene method as modified by Nelson and Somers *(4)*.

Carotene and Total Alcohol-Extractable Pigments. Each package was sampled individually. Sixty-gram samples or equivalent weights of the desiccated vegetables were mixed in a Waring Blendor for 3 to 5 minutes with 40 ml. of distilled water. The weight difference of the desiccated samples was compensated for by increasing the amount of water. An aliquot of the slurry was weighed into an aluminum weighing dish and dried 20 to 24 hours at 70° C. A 20 to 30 gram portion of the slurry (10 gm. of spinach slurry) was weighed by difference into an Erlenmeyer flask which had a spherical joint. The slurry aliquot was extracted twice with 95 percent ethanol by refluxing on the steam-bath for 15 to 20 minutes.

For the carotene determination, an aliquot of the filtered alcohol extract was transferred to a separatory funnel; 45 ml. of petroleum ether (Skellysolve B), 15 ml. of 10 percent alcoholic KOH, and 15 ml. of water were added. The mixture was shaken thoroughly after each addition. After drawing off the aqueous layer, the petroleum ether layer was washed three times with distilled water. Anhydrous sodium sulfate was added to dry the petroleum ether extract before transferring to a 50 ml. volumetric flask. Aliquots of the extract were chromatographed on soluble starch-Hyflo-Supercel columns (1 part starch—2 parts Supercel). The percolates were adjusted to 10 ml. and read in the Evelyn photoelectric colorimeter using a 440 mμ filter.

Total alcohol-extractable pigments were determined on the same extract used for the carotene determination. On the basis of the solids content of the original slurry, an aliquot of the alcohol extract was pipetted into a 25 ml. graduated cylinder and made up to volume. A small quantity of Supercel was added to clarify the alcohol extracts. The Supercel-treated extracts were filtered and read in the Evelyn colorimeter at 440 mμ and 660 mμ. Chlorophyll and carotenoids are measured by this technique.

Munsell Colors. The colors of the thawed raw vegetables and the cooked vegetables were compared according to the Munsell system of color notation which expresses color in units of visual difference of the three psychological attributes: hue, value, and chroma *(3, 5)*.

The scoring system for hues ranges from 0 to 10 within each hue designation, i.e. 10 yellow is the equivalent of 0 green-yellow. The values range from 1 or black to 10 or white; chromas range from 1 to 10. Munsell chroma (for all colors possessing hue) is that attribute which determines their degree of difference from a gray of the same value.

Photography. Samples of the vegetables were photographed in color and in black-and-white in the freezer, at room temperature after three hours' thawing, and after cooking. The samples stored in parchment bags were not photographed. The pictures of green beans and corn were taken after nine months' storage, spinach after seven months' storage, and peas after one month's storage.

Results

Moisture Losses. Moisture losses from the foil bags were negligible, but cavity ice formation within the packages was severe in spite of the lead foil lining. The cavity ice is clearly visible in the photographs of the frozen vegetables (Fig. 1, 2, 3, 4). Moisture losses (Table 1) from the vegetables stored in parchment bags were large and continuous, ranging from 11.5 percent for green beans to 25.0 percent for spinach after 12 months' storage.

TABLE 1

Moisture Losses from Frozen Vegetables Stored in Parchment Bags

Vegetable	Average Moisture Losses per Package*							
	3 months		6 months		9 months		12 months	
	gm.	%†	gm.	%†	gm.	%†	gm.	%†
Green beans	3.6	1.4	11.1	4.4	19.2	7.7	28.8	11.5
Corn	2.8	1.2	9.8	3.9	17.6	7.0	42.4	16.9
Spinach	13.6	5.4	22.8	9.1	40.6	16.2	62.7	25.0
Peas	10.8	4.3	14.9	6.0	35.5	14.2	60.1	23.9

* 250 gm. of the frozen vegetable were placed in each parchment bag.
† Expressed on basis of original net package weight.

Rehydration Capacity. In Table 2 the weight of cooked vegetable plus solids in the cooking water is

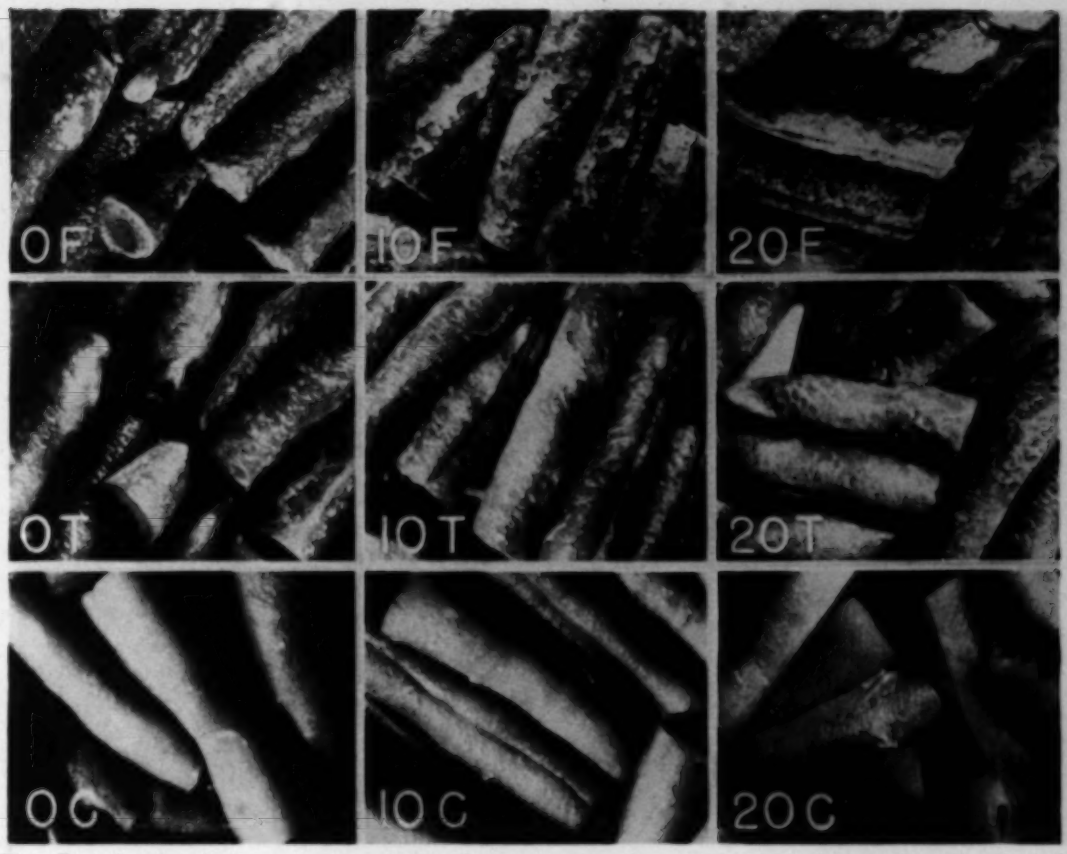

FIG. 1. The effect of desiccation on green beans held in frozen storage; after thawing; and after cooking. 0 = no moisture loss before storage; 10 = 10 percent weight loss; 20 = 20 percent weight loss; F = frozen, T = thawed, C = cooked.

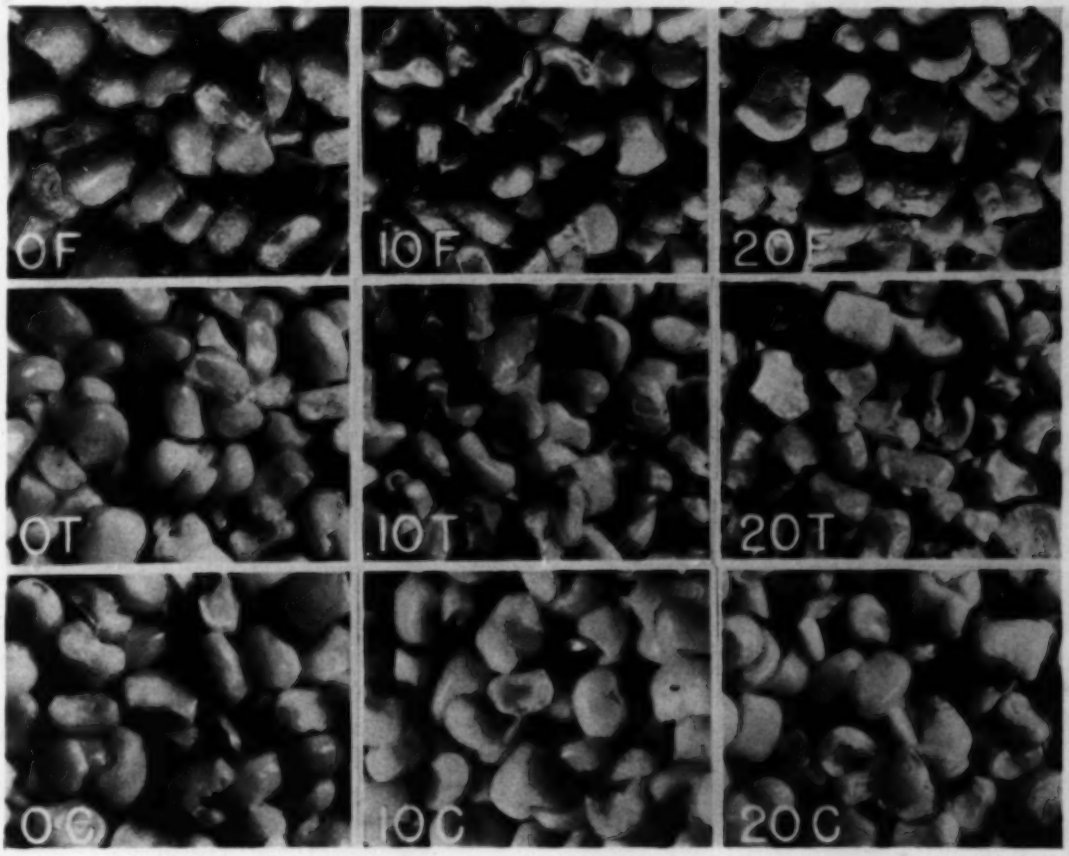

FIG. 2. The effect of desiccation on corn held in frozen storage; after thawing; and after cooking. 0 = no moisture loss before storage; 10 = 10 percent weight loss; 20 = 20 percent weight loss; F = frozen, T = thawed, C = cooked.

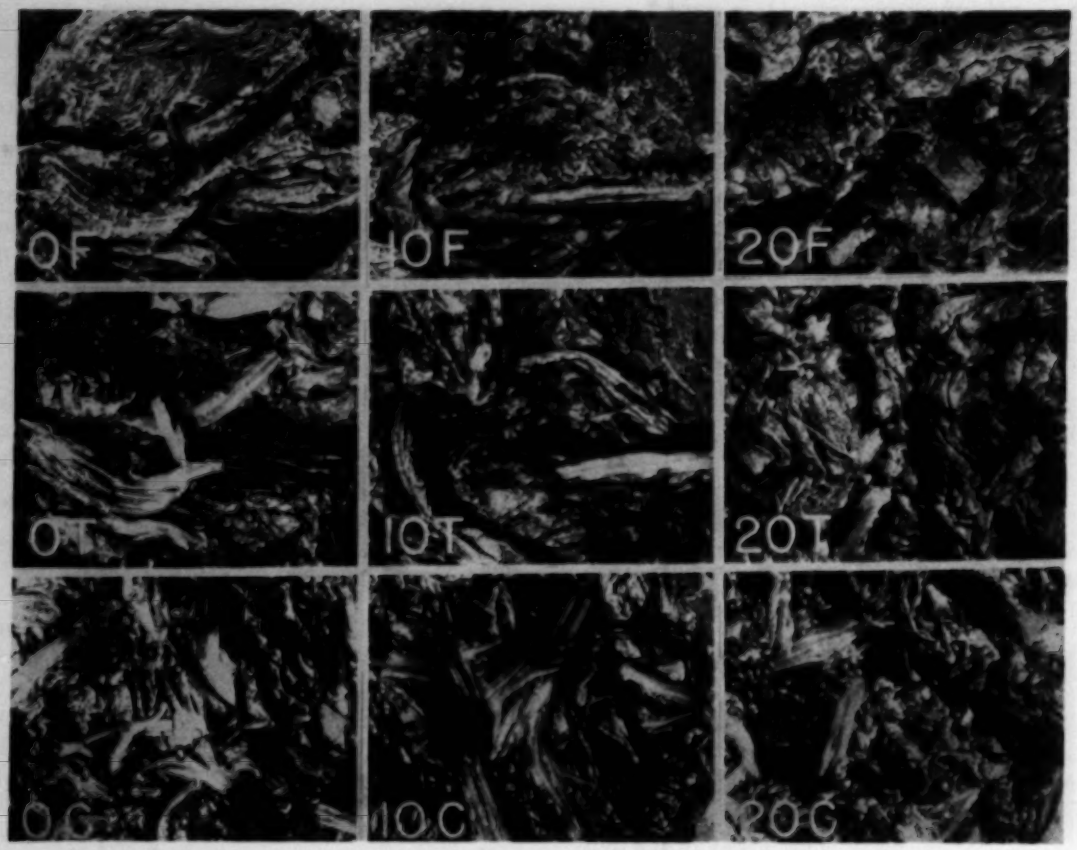

FIG. 3. The effect of desiccation on spinach held in frozen storage; after thawing; and after cooking. 0 = no moisture loss before storage; 10 = 10 percent weight loss; 20 = 20 percent weight loss; F = frozen, T = thawed, C = cooked.

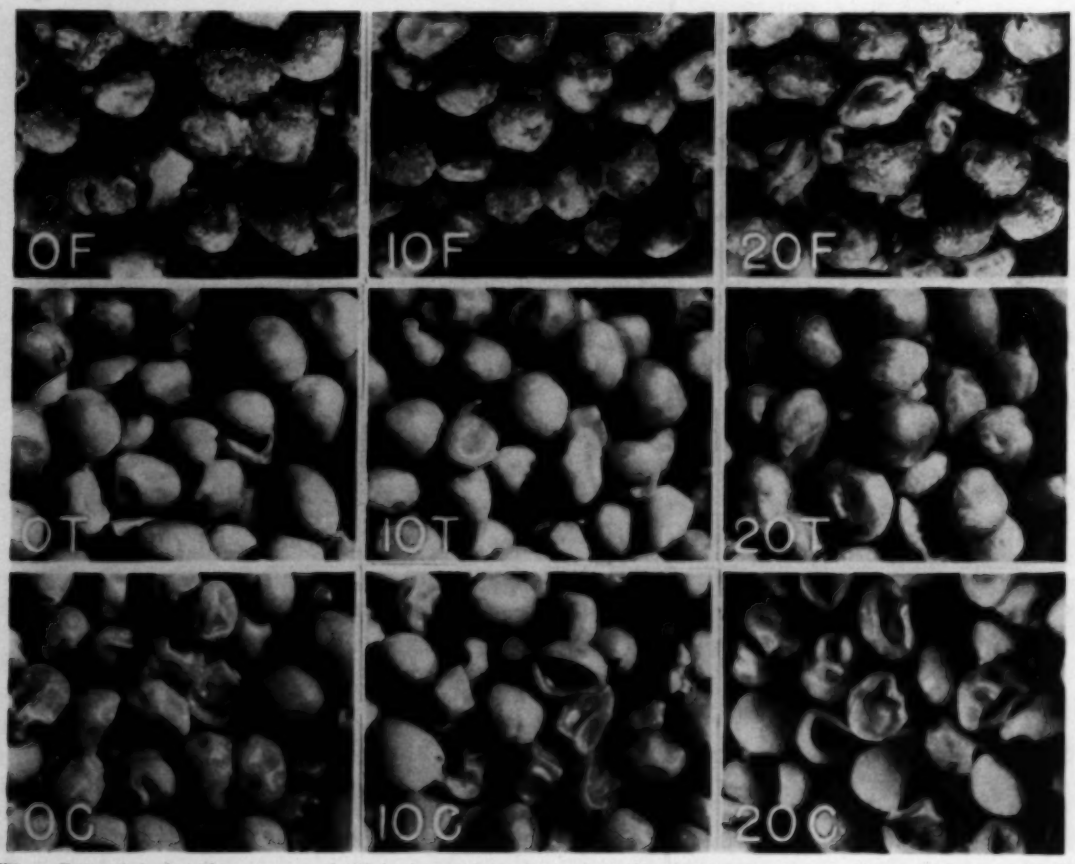

FIG. 4. The effect of desiccation on peas held in frozen storage; after thawing; and after cooking. 0 = no moisture loss; 10 = 10 percent weight loss; 20 = 20 percent weight loss; F = frozen, T = thawed, C = cooked.

TABLE 2

Rehydration Capacity of Frozen Vegetables Used in Desiccation Studies

Vegetable	Desiccation treatment	Cooked Vegetable Plus Solids in Cooking Water				
		Initial gm.	3 months gm.	6 months gm.	9 months gm.	12 months gm.
Green Beans	0*	100.5	105.8	107.3	101.2	88.0
	10	97.9	104.1	107.4	93.1	90.5
	20	99.5	96.2	93.9	106.9	89.5
	x†	....	93.4	108.7	106.9	90.0
Corn	0	115.5	118.8	114.2	115.5	115.9
	10	120.8	112.7	116.2	116.2	113.9
	20	116.0	109.8	111.9	108.2	111.8
	x	....	119.6	119.1	120.8	108.5
Spinach	0	109.3	101.2	109.6	94.7	106.2
	10	103.9	106.2	108.6	107.3	102.9
	20	107.2	103.1	118.8	97.8	102.9
	x	....	98.4	103.6	110.1	105.6
Peas	0	101.9	92.2	89.7	86.3	94.9
	10	95.8	93.5	83.7	76.7	97.6
	20	94.1	88.2	94.0	93.9	92.8
	x	....	94.2	89.7	83.8	88.8

* 0, 10, 20 are the percent weight losses resulting from desiccation of the vegetables before packaging in foil-lined bags.

† No desiccation treatment before packaging in vegetable parchment bags. See Table 1 for moisture losses from the different vegetables at each sampling period.

given. This is referred to as rehydration capacity. Of the four vegetables only the peas showed a decreased rehydration capacity, and even this was not proportional to the extent of desiccation. The green beans showed a lower rehydration capacity regardless of desiccation at twelve months but not at the other sampling periods. Corn and spinach showed only slight and inconsistent changes in rehydration capacity during the study. Thus the ability of desiccated vegetables to resorb water during cooking is not impaired during prolonged freezer storage.

Palatability Scores. The palatability scores given in Table 3 represent the average score by five judges. The

TABLE 3

Palatability Scores for Frozen Vegetables Used in Desiccation Studies

Vegetable	Desiccation treatment	Palatability Scores for Cooked* Vegetables				
		Initial	3 months	6 months	9 months	12 months
Green Beans	0†	53	73	51	58	64
	10	88	92	92	92	87
	20	90	83	87	93	87
	x‡	....	66	45	59	59
Corn	0	76	73	82	69	82
	10	60	78	80	86	85
	20	70	83	77	90	79
	x	....	77	74	79	76
Spinach	0	83	79	93	84	90
	10	79	78	79	88	93
	20	82	93	85	79	71
	x	....	92	88	93	88
Peas	0	88	86	90	76	78
	10	91	87	72	75	73
	20	91	77	87	75	69
	x	....	82	76	77	87

* Cooking time after the water returns to boiling: Green beans, 10 min.; corn, 5 min.; spinach, 6 min.; peas, 5 min.

† 0, 10, 20 are the percent weight losses resulting from desiccation of vegetables before packaging in foil-lined bags.

‡ No desiccation treatment before packaging in vegetable parchment bags. See Table 1.

green beans desiccated before storage consistently showed a higher score than either the control or those stored in parchment. This unusual observation was due in part to the color of the cooked beans. The controls were a dull olive-brown color whereas the desiccated beans were green after cooking. The unexpected result could possibly have been caused by removal of volatile acids during the desiccation period, the acid decrease being sufficient to avoid the excessive formation of pheophytin from chlorophyll during the cooking process. The difference in hue of the cooked beans according to the Munsell color system was distinct. The data in Table 7 also show that the control beans in both foil and parchment changed to a higher green-yellow hue as the storage progressed, thus bearing out the suggestion that volatile acids were perhaps the responsible factor. The desiccated beans were rated as being more tender and having better flavor than the controls at each sampling period. The scores for beans within any one desiccation treatment showed only slight differences between storage periods.

The palatability scores for corn and spinach remained essentially constant with only slight differences which reflected neither desiccation treatment nor length of storage. Peas showed a somewhat different effect in that the palatability scores of all samples gradually decreased during storage, the initial mean score of 90 dropping to 83, 81, 76, and 77 after 3, 6, 9, and 12 months' storage, respectively. The decreased score was due to a general decline in all five factors on which the peas were scored, but flavor was the largest factor contributing to the decrease. However, there were no consistent differences between the desiccated and control samples.

Ascorbic Acid. The ascorbic acid values for the four vegetables are given in Table 4. Six samples of beans,

TABLE 4

Ascorbic Acid in Frozen Vegetables Used in Desiccation Studies

Vegetable	Desiccation treatment	Milligrams Ascorbic Acid per 100 Grams Fresh Vegetable				
		Initial	3 months	6 months	9 months	12 months
Green beans	0*	4.5 ± .3	3.4	2.8	4.1	3.6
	10	3.6	2.5	3.3	3.5	4.1
	20	3.7	2.7	3.2	3.8	3.5
	x†	....	2.6	3.3	3.4	3.4
Corn	0	7.2 ± .4	7.8	6.5	6.8	6.4
	10	7.0	7.3	6.4	6.5	6.1
	20	7.0	7.0	5.6	6.1	5.6
	x	....	7.6	6.5	6.5	6.1
Spinach	0	25.9 ± 4.1	15.4	13.7	13.4	7.8
	10	24.6	15.1	14.6	17.0	12.2
	20	26.5	15.1	14.1	9.0	5.9
	x	....	19.3	15.5	13.2	9.7
Peas	0	12.2 ± 1.3	12.3	12.0	11.2	4.7
	10	12.0	9.2	6.5	5.2	3.8
	20	12.1	9.6	9.8	7.3	4.6
	x	....	12.3	8.6	10.9	6.0

* 0, 10, 20 are the percent weight losses resulting from desiccation of the vegetables before packaging in foil-lined bags.

† No desiccation treatment before packaging in vegetable parchment bags. See Table 1.

corn, and spinach and seven samples of peas were analyzed to determine the standard deviation of the initial control samples. The desiccation treatment before storage decreased slightly the ascorbic acid of green beans, but the other vegetables showed no change. All treatments of green beans and corn showed slight decreases after 3 and 6 months' storage, respectively. Although the ascorbic acid content of spinach and peas

was not influenced by desiccation, both showed marked decreases of approximately 60 percent of the original vitamin during storage at 0° F.

Carotene. The concentration of carotene in the four vegetables is given in Table 5. Six samples of corn and peas, five samples of beans, and four samples of spinach were analyzed to determine the standard deviation of the initial control samples. Carotene values remained relatively constant throughout the entire storage study regardless of desiccation treatment.

TABLE 5

Carotene in Frozen Vegetables Used in Desiccation Studies

Vegetable	Desiccation treatment	Milligrams Carotene per 100 Grams Fresh Vegetable				
		Initial	3 months	6 months	9 months	12 months
Green beans	0*	.37 ± .02	.35	.32	.33	.32
	10	.37	.38	.36	.36	.36
	20	.40	.37	.32	.36	.35
	x†	....	.39	.38	.37	.34
Corn	0	.22 ± .01	.26	.23	.26	.27
	10	.24	.23	.27	.26	.27
	20	.22	.22	.25	.28	.22
	x	....	.22	.24	.26	.24
Spinach	0	5.12 ± .42	5.48	5.76	5.39	4.05
	10	5.41	6.11	6.11	5.31	4.65
	20	5.40	6.03	5.82	5.36	5.48
	x	....	5.54	5.39	5.78	4.48
Peas	0	.41 ± .02	.45	.43	.41	.43
	10	.40	.43	.41	.40	.48
	20	.40	.46	.37	.44	.41
	x	....	.44	.41	.49	.49

* 0, 10, 20 are the percent weight losses resulting from desiccation of the vegetables before packaging in foil-lined bags.
† No desiccation treatment before packaging in vegetable parchment bags. See Table 1.

Total Alcohol-Extractable Pigments. The pigments which were extracted from the vegetables by refluxing with ethanol were read colorimetrically. The readings showed only slight and inconsistent variations which were related to neither desiccation nor storage time. To give a measure of the relative concentrations of the pigments in the four vegetables, the extinction coefficients of the alcohol extracts of the controls determined at the beginning of the study are given in Table 6.

TABLE 6

Extinction Coefficients of the Total Alcohol-Extractable Pigments in Four Frozen Vegetables

Vegetable	Solids extracted mg./ml.	Filter mμ	G*	E†
Green beans	2.5	440	44	141
	5.0	660	55	52
Corn	10.0	440	66	18
Spinach	.25	440	41	1549
	.50	660	53	551
Peas	5.0	440	45	69
	5.0	660	76	24

* G = corrected galvanometer reading (percent transmission)

† $E = \text{extinction coefficient} = \frac{2 - \text{Log G}}{\text{gm. solids/ml. of solution}}$

Munsell Colors. The colors of both the raw and cooked vegetables were determined at each sampling period by the Munsell system of color notation. The initial, six, and twelve month data for the cooked vegetables are included in Table 7. The notations for the raw, thawed vegetables showed variability unrelated to the desiccation treatment or the length of storage. For purposes of comparison with the cooked samples the Munsell notations for the thawed, undesiccated products initially were:

Vegetable	Hue	Value	Chroma
Green Beans	6.8 GY	4.0	4.5
Corn	3.0 Y	7.2	8.8
Spinach	5.9 GY	2.9	3.1
Peas	5.5 GY	4.4	5.3

The appearance of the thawed vegetable is not always observed for the general recommendation to consumers is to place the frozen food into the cooking water directly. Therefore, the color and general appearance of the cooked product are of much greater importance than those of the raw, thawed product.

As already noted, the color data (hue) indicate that considerable hydrolysis of chlorophyll occurs during the cooking of green beans, and that desiccation has tended to minimize this change. Corn, spinach, and peas, when

TABLE 7

Munsell Color Notations for Cooked Frozen Vegetables Used in Desiccation Study

Vegetable	Desiccation treatment	Storage Periods — Months								
		Initial			6			12		
		Hue	Value	Chroma	Hue	Value	Chroma	Hue	Value	Chroma
Green beans	0*	9.2Y	3.9	3.1	.6GY	4.0	3.3	1.2GY	3.9	3.6
	10	2.2GY	4.0	3.2	2.6GY	3.8	3.2	2.5GY	4.0	3.7
	20	1.3GY	4.0	3.4	1.2GY	3.8	3.1	2.5GY	4.0	3.8
	x†	....	....	....	.9GY	3.9	3.1	1.4GY	4.0	3.5
Corn	0	3.2Y	7.3	8.8	3.0Y	7.2	8.6	3.3Y	7.3	9.0
	10	3.4Y	7.3	9.1	2.9Y	7.2	8.7	3.2Y	7.3	9.0
	20	3.8Y	7.3	9.0	3.2Y	7.3	8.9	3.3Y	7.3	9.0
	x	....	....	....	3.2Y	7.3	9.2	3.3Y	7.3	10.0
Spinach	0	4.9GY	2.8	2.5	3.4GY	2.6	2.8	5.1GY	2.7	2.3
	10	5.0GY	3.0	2.7	4.5GY	2.5	2.2	4.8GY	2.7	3.0
	20	4.9GY	2.8	2.4	3.9GY	2.9	2.2	4.8GY	2.7	3.0
	x	....	....	....	4.6GY	2.8	2.2	4.9GY	2.8	2.9
Peas	0	5.3GY	4.5	6.8	5.1GY	4.5	6.7	5.0GY	4.3	6.4
	10	5.2GY	4.4	6.9	5.1GY	4.6	6.3	5.4GY	4.0	5.9
	20	5.3GY	4.4	6.9	5.1GY	4.5	5.5	5.6GY	4.3	5.5
	x	....	....	....	5.4GY	4.6	6.2	5.1GY	4.4	5.9

* 0, 10, 20 are the percent weight losses resulting from desiccation of vegetables before packaging in foil-lined bags.
† No desiccation treatment before packaging in vegetable parchment bags. See Table 1.

cooked, showed no important color changes during frozen storage or desiccation.

Photography. The photographs (Fig. 1, 2, 3, 4) show clearly that the control and desiccated vegetables were indistinguishable after cooking. The frozen, desiccated vegetables were easily distinguished by the surface drying and shrunken areas. The thawed vegetable pictures also showed the difference between control and desiccated samples, but the differences were much less distinct.

Discussion

The data reported here clearly show that even though desiccation seriously damages the appearance of frozen vegetables, the rehydration which occurs during cooking restores the color and appearance. Palatability scores and ascorbic acid contents are much more seriously affected by the twelve months' storage in the freezer than by the desiccation treatment. The carotene content and total alcohol-extractable pigments are not altered by the desiccation treatment. Under the conditions of this study, no deleterious change in appearance, nutritive value, flavor, or texture ascribable to moisture loss could be detected in the product as prepared for the table.

In light of these numerous observations the recommendation for using highly moisture-vapor resistant wraps to prevent drying of frozen vegetables is subject to qualification. For commercial products, the need for preventing desiccation, loss in net weight, and the accompanying undesirable appearance of the vegetable *while still frozen* remains. For locker plant or home-frozen products, where sales appeal and container fill are not factors, good quality frozen vegetables can be obtained even when the more permeable wrapping materials are used.

We wish to emphasize that these observations and conclusions do not necessarily apply to frozen fruits, or to meat, fish, or poultry. For frozen vegetables, however, it appears that the importance of vapor-proof wraps and of minimizing cavity ice formation *(7)* has been overemphasized.

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Nicholas Appert Medal Presentation

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Chairman, Chicago Section

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July 12, 1949

Have you ever received a letter which expressed in simple terms sincere appreciation for a service rendered or a job well done? I am sure that each and every one of you has experienced that slight tingle of pride which accompanies such commendation. It's nice to know that someone is kind enough to express himself in this manner. And it's a nice feeling to transmit such appreciation, too. Every time I see such a letter, I cannot help thinking—"Flowers for the living!"

Appert, whose name and work is honored through the presentation of the annual Nicholas Appert Medal Award, was recognized and rewarded for his important contribution while he was still living and active. It was with this same idea in mind several years ago that the Chicago Section instituted this annual award so that recognition of outstanding work in food technology could be acclaimed during the active career of the recipient.

It is not my intention at this time to repeat a review of the life and work of Nicholas Appert. Historical record contains these details. I do feel justified, however, in taking a little time to clarify an important point in the annual selection of a medalist.

Each year the Executive Committee of the Chicago Section elects three Award jurors to serve for a term of three years. Thus, there are nine jurors. Each is a member of the Institute of Food Technologists and is a well recognized authority in his own field. A balance is maintained in the selection of jurors so as to have representatives of the various sections of the country and the several fields of food technology. The Chairman of the Chicago Section acts as Chairman of the jury but has no vote. The identity of the jurors is kept confidential within the Executive Committee of the Chicago Section. Except for chance exchange of information between jurors, they themselves do not know the identity of the other members of the jury. All nominations for medalists and all balloting is conducted as private correspondence between the individual juror and the Chairman of the jury.

I have taken pains to elaborate this point because of obvious misunderstanding on the part of some members of the Institute as to the method of selection of the medalist. No officer or member of the Chicago Section has anything to do with the selection of the annual medalist except in a rare instance as an elected juror. The annual selection of a medalist rests entirely in the hands of the jury who, in the past, has elected to honor such distinguished food technologists as Dr. William V. Cruess, Dr. Samuel C. Prescott, Dr. Charles A. Browne, Dr. Avrill W. Bitting, Dr. Clyde H. Bailey, Dr. C. Olin Ball, and Dr. Conrad A. Elvehjem. Tonight we are adding another name to that illustrious list.

The recipient of the Nicholas Appert Medal Award for 1949 is Dr. Roy Chester Newton. Dr. Newton was born in Oklahoma in 1896. This was shortly after his pioneering father acquired land rights as a participant in one of the famous Oklahoma land rushes. Roy Newton's early schooling was in the Stillwater public schools. He then entered Oklahoma A. & M. College. Shortly thereafter, his undergraduate studies were interrupted by World War I. As a Second Lieutenant in the Infantry, he won glory and fame in the St. Mihiel and Argonne Sectors, receiving the Croix de Guerre with Silver Star in recognition of his admirable service. With the war over, he returned to school to receive his degree of Bachelor of Science in Chemical Engineering in 1921. Graduate work was undertaken at the University of Chicago, where, after an interlude as an instructor in chemistry at Purdue University, he received his Ph.D. degree in 1924. That same year he started to work for Swift & Company as a research chemist, being subsequently promoted to Assistant Chief Chemist in 1929 and to Chief Chemist and Director of the Research Laboratories in 1931. In 1941 his company named him Vice President in Charge of Scientific Research, his present position.

Dr. Newton's main contributions to food science and food technology have been in the fields of fats, oils, and emulsions. His principal work has been with respect to anti-oxidants, crystallization and deodorizing. As would be expected, other investigational studies led him into the fields of meat preparation, meat curing and preserving, gelatin, glue, eggs and cheese. He holds numerous patents. His genuine modesty and sincere interest in his staff and its work has led to a tendency to assume an anonymous role in the investigational reports issuing from the Research Department which is working under his guidance and direction. He is rather unique in that he has published practically nothing. He is more than content to permit the publication of important scientific reports under the name of the investigator doing the principal work, even though this work might be under his personal direction. He exemplifies an often overlooked, but exceedingly important, facet of the food technologist and that is the role of management and direction.

Many attempts have been made to define food technology and the food technologist. I recall one individual who felt that the real description of a food technologist was that of a scientifically trained member of management who had the ability to assemble and shape into useful productive channels all of the scientific information worked out by the technicians. It certainly is not my intention to introduce a controversial subject at this time but the honors that already have been accorded to our present medalist have all stressed the wide-spread appreciation of the tremendous contributions made by Dr. Newton as an organizer, developer, manager and scientific director of an outstanding industrial research laboratory. Under his able guidance this laboratory has made many valuable contributions to the general knowledge of foods, their production, preservation and improvement for the benefit of mankind as well as for the parent organization that sponsors this research.

Roy C. Newton has received the Scroll of Honor of the Chicago Section of the American Institute of Chemists. The Agricultural Alumni of Purdue University have awarded him their Certificate of Merit. He is in the Hall of Fame of his Alma Mater, Oklahoma A. & M. College. General dependence upon Dr. Newton's ability, wise counsel, and unselfish energy is attested by his concurrent service on no less than 24 scientific boards and committees. Just to mention a few of these, he is a member of the Board of Trustees of the George Washington Carver Foundation; he is Chairman of the Agricultural Board of the National Research Council; he is a member of the Scientific Advisory Council of the Refrigeration Research Foundation, Inc.; he is Advisor to the Research and Development Branch, Office of the Quartermaster General and is a member of the Board of Directors of Associates Food and Container Institute.

He was the first elected Vice President of the Institute of Food Technologists and later was honored by election to the Presidency of our organization. I can personally attest to the fact that he is a vigorous member of the Chicago Section, taking active interest in all important local and national affairs.

Dr. Newton looks back with great personal pride on two achievements which he considers his outstanding contributions—first, his service to his country in World War I, and second, his privilege and ability to organize, develop, manage and direct scientific research for his company. I am sure he subscribes to the words of Theodore Roosevelt, who said: "Far and away, the best prize that life offers is the chance to work hard at work worth doing."

Much of the personal data given with reference to our medalist is merely an embellishment of some very carefully chosen words which appear in the Nicholas Appert Medal Award rules. It is interesting to note at this point that these rules were drawn up several years ago by Dr. Newton, together with others. Rule No. 2 of the Award states: "The Award shall be made . . . to anyone who, because of his pre-eminence in and contribution to the field of food technology, is deemed worthy of special recognition by the jury."

Dr. Newton, it is with a profound feeling of national honor, local pride and personal thrill that I present to you, in behalf of the Chicago Section of the Institute of Food Technologists, the Nicholas Appert Medal for pre-eminence in and contribution to the field of food technology.

ROY C. NEWTON

Vice-President in Charge of Research and Development, Swift & Company.

Science on Trial

ROY C. NEWTON

Nicholas Appert Medal Award Address, Institute of Food Technologists
July 12, 1949

When I was notified that I would be called upon for an address at this very momentous occasion in my life, I thought of two subjects that have attracted my recent interest. The first of these may be called "The Food Technologist's View of Nutrition," and the second might be titled "Science on Trial." Don't be surprised if I stray from one to the other since there is a natural and very fundamental bridge in the fact that food technology like some of the other professions is based on the facts developed by the methods of science. Also, the future progress of food technology depends upon a healthy and rigorous program of scientific research.

Food technology was born when science began to replace art in the processing and handling of food. I say "began to replace art" advisedly, because such replacement has not been complete and from our present view it would seem that complete replacement of art is a long way off if, indeed, it is ever to be accomplished.

In the selection and preparation of food, man like all other species of animals has depended on his senses of sight, touch, smell, and taste, almost exclusively as his guide. In our present language these are interpreted as appearance, texture, odor or aroma, and flavor.

History shows two important characteristics of man with regard to his use of these senses whenever food supply has been abundant or even adequate. First, he becomes more choosy and selective when the opportunity presents itself through abundance. Second, preferences for those qualities in food are established according to availability.

The establishment of preferences probably has its origin in an era of scarcity. Once such preferences are established in a racial or national group, they may carry on for many generations because foods which meet these requirements are made available in the home to the next generation even though a wider selection might be possible.

Food technologists receive their remuneration and thus their encouragement from their contribution to the fulfillment of these preference requirements.

It will be seen then, with the melting pot of numerous groups of diverse habits in this country, why the food technologist here has so much more difficult problems than in a more homogeneous national population.

The profession of food technology arises from the necessity of applying scientific principles to the improvement of appearance of package, appearance of product in the package, texture and flavor of the product on the table. These requirements provided the impulse for improvement before the real purpose of food, its nutritive quality, reached the consciousness of the American public. In fact, they still occupy a more important place in the minds of people, which constitute the consuming public. It is not strange then that the development of food technology should have been along the path of improving these qualities rather than the conservation of nutrients. The unusual mixture of engineer and scientist, which we call the food technologist, watching his brother scientist in the field of human nutrition, has caught a spark of his idealism.

He has blended this idealism with his practical commercial sense and come to the conclusion, during the past ten years or so, that the food processor must not only satisfy the wants of the consumer as enumerated a moment ago, but must also satisfy the needs of the consumer for all of the nutrients. This is a most important step in the evolution of the profession of food technology. It broadens and complicates the food technologist's problems, but, more particularly, it adds a new responsibility. This new responsibility to consider the effect of each new process or package on nutrient quality is one which, I believe, is now firmly established in the minds of this professional group.

Let us examine this new requirement in the light of our past experience and the modern concept of nutrition.

In the first place, nutrients must come from food. There may be vast expenditures of advertising money directed to the sale of purified or synthetic ingredients which provide one or a few of the many nutrients. I have no quarrel with this advertising as I believe it all helps to educate the public. It should be evident to all of us, however, if we carried this to its logical conclusion and purified each of the nutrients and then blended them into a ration that we would have a very expensive and tasteless food. For this reason, I believe, the food technologist will make his greatest contribution by giving his attention to foodstuff of natural origin. Our background of experience teaches us that people will eat those foods which meet their preference requirements as measured by the senses. In other words, the first principle of good nutrition is food that tastes good.

As food technologists then, we find our new responsibility of nutrient conservation neatly blended with our oldest ambition, namely, to improve that indescribable thing we call eating quality. But, eating quality or palatability is no longer a complete criterion for the success of a new process. We must now be sure that the natural foods which man in his long struggle for survival has selected by his senses are not rendered deficient in the nutrients which nature has provided for his well-being. Fortunately, the nutritionist has furnished us with the tools and methods of measuring the nutritive quality of foods and the possible destruction of nutrients during processing.

The food technologist is also concerned with food supply at all seasons of the year and in all geographical areas. This has always presented problems of deterioration in palatability. We now recognize the possible deterioration of nutritive quality and are thus faced with new problems of storage, packaging, and distribution.

There is every evidence that the consuming public will with further education become more conscious of nutritive quality and exercise even more its selection of food by this criterion. Honest advertising will augment this trend and rightfully so. It, therefore, behooves the technologist to know his foods from the standpoint of their nutrients, and to exert his influence toward honesty in advertising.

At the moment there seems to be no instrument of education which carries as much influence as advertising. This imposes a moral responsibility on each food processor and his technologists to make this influence constructive.

Natural science was once an integrated division of philosophy. A learned man was one who possessed advanced knowledge of all branches of philosophy including natural science.

As the boundaries of knowledge were pushed back, the area became too large for any one mind to encompass. The detail in any phase of learning became so vast that specialization became necessary. Breadth of interest could only be maintained at the expense of depth and the real pioneers became those who were willing and able to limit their interest to some narrow field and pursue it to the periphery of the accumulated knowledge. Only by such procedure could new secrets of nature be brought to light. Thus were established the various branches of natural science and thence the sub-branches, to the extent that many of our greatest scientists are deep in their particular field but narrow in scope. Our generation has been marked by such a degree of specialization that workers in one field could no longer talk the language of those in another. Some of the most dramatic episodes in science have been associated with the overlapping and merging of the intricate subbranching of two or more phases of natural science. These cases have served to confirm the soundness of each approach and have become especially useful where one science has provided instruments and techniques for the other.

The struggle to endow the biological sciences with a degree of exactness has witnessed the dependence on chemistry, physics, and mathematics. All of the sciences have drawn heavily on mathematics as they were developed to that stage of exactness which has made them most useful to man. There are so many illustrations of this that one might hazard the generalization that the use of mathematics is the distinguishing characteristic of the natural sciences as contrasted with the rest of the whole field of philosophy.

The biological sciences were among the first in man's experience with nature. The apparent backwardness in the development of these branches of science is due primarily to the difficulty in the perfection of methods of exact measurement of experimental phenomena.

Just as the sciences of mathematics and physics have improved the art of engineering so has chemistry and the biological sciences improved the art of medicine. It should be carefully noted that it is in the area of overlapping of the various branches of science that the utility of each is most often brought to bear on man's problems.

And, so we repeat, food technology is based on facts enunciated as a result of scientific research. Since the progress of our profession is dependent on the progress of science, we are concerned with factors which may influence science and the work of scientists.

There are some of us who believe in scientific research as man's greatest achievement and as man's greatest promise for future progress. There is need for government supported research programs. The excellent work in the Agricultural Experiment Stations, and other Government institutions has proven their usefulness. The question now is how much further the Government can go into scientific research without destroying its effectiveness.

The endowed universities have been able to maintain the degree of independence which is necessary for advanced education and research. Largely because of the standard set by these endowed institutions, the tax supported universities have been able to maintain a degree of freedom and make notable contribution to the advancement of human knowledge. Tax money has thus been utilized for the welfare of man. Scientific research has flourished only where the workers have been free from regimentation. It is my considered opinion that the extent of success is proportional to the degree of freedom which has been maintained. The trend seems to me to be clearly marked and indicates more and more regimentation by Government bureaus in every phase of our national life in which the people are willing to delegate the authority and appropriate the money. The future progress of man depends more on scientific research than any other factor, and this, in turn, depends on freedom from control.

The Steelman report on Science and Public Policy outlined eight large areas of action for the United States. These covered largely the same general recommendation made in the earlier Vannevar Bush report. Most of these points are those for which the scientists have been working for years. Perhaps this explains why the scientists have so eagerly accepted these reports and their recommendations without the careful analysis which would signify a scientific approach. There are, however, some very large questions which remain unanswered. The scientist at this time is not unlike the poor man who did some very foolish things in anticipation of inherited wealth. The charlatan's promise of easy money to the scientist is no more capable of fulfillment than when made to the masses of people. The difference to be expected is that the scientist should be able to see through such a thin veil of anticipation and distinguish more clearly those roads which lead to Utopia. The scientist should know more clearly than anyone the value of that freedom which must be given up for the political easy money. He should see also the place from which the political body gets the money and what might have been done with the money if it had not been taken. The scientist should be able to balance cause and effect to determine the price being paid for such easy money.

The Steelman report raises the question—"What is government responsibility?" and answers it with the following words:

"Demarcation according to sound principles between the activities of Government research installation and the laboratories of industry and of universities is important. It may not be so difficult to define appropriate areas of emphasis in general terms, but the application of broad principles of public interest calls for close and continuing attention."

I do not know which member of the Steelman staff wrote that paragraph, but I surely agree that " . . . the application of broad principles of public interest calls for close and continuing attention." In my judgment, the government has a very grave responsibility along two different lines, first, to be sure that the money, the enormous amount of money, does not destroy good research programs by hiring the personnel, second, that the tax necessary to raise this easy money doesn't rob industry of its research budget, or, in the end, its production capital.

I do not believe it is possible to place huge sums of money for research purposes in the hands of a few people, whether they be foundations or government bureaus, without defeating the very purpose for which the money was allocated. Now, how much is a "huge" sum? The answer is that amount of money which will bring about any or all of three very bad effects, namely, (1) divert by purchasing power the attention of scientific talent from fields of their interest to fields which happen to have more adequate finance; (2) divert funds from private research programs to government controlled research by excessive taxation; (3) dissipate the feeling of responsibility of the private citizen and private corporation to conduct its own research. The last named is the most insidious effect of all.

We are gradually delegating authority to Government to take over the individual's responsibility to provide those necessities of life essential for the maintenance of his home and family.

Through many other equally subtle manipulations we are giving up our freedom of action for a promise of a "free lunch." If we give up the freedom of science, then hope for the future is lost. That is the reason I am opposed to a government supported program that overbalances privately supported research.

The tendency for scientists to reach for this government easy money is alarming. Paternalism of a government toward any class of its citizens is not only dangerous as a threat to the freedom of individuals in that class but is degrading to individual initiative. A nation which embraces such philosophy has taken a step toward the destruction of those elements of character which make its people strong. It is easy for a politician to promise patronage to each group of his constituents. To fulfill these promises even though the patronage is equitably distributed is impossible except to the extent that these same groups are taxed to supply the funds. The waste involved in channeling this tax money through a government agency has reached enormous proportions as indicated in the report of the Hoover Commission. This waste, however, large as it is, is a small item compared to the intangible faults in such a system. The false hope that prosperity and progress can come from any source except work and production is a free-lunch-philosophy that destroys initiative. Individual initiative is the basic ingredient in all progress, whether it be industrial production or fundamental scientific research.

The scientists of this country should consider carefully the source of their financial support. The institution should be careful to see that the balance between controlled funds and independent resources is maintained. It is the proportion of independence which will guarantee the freedom of all scientific work and eventually influence the freedom of all of our American institutions.

The fountain of scientific thought is in the universities, but the contemporary scientists in industry have a stake in this question of scientific freedom. The industrial scientist has as his first objective the contribution toward the effort of his company to perform a useful service to society. This is his obligation to the public, to the shareholders of his company, and to his fellow employees. It must be perfectly evident to him that he cannot fulfill these obligations if the fountain of new knowledge in the universities is allowed to dry up.

During the fast pace of industrial development brought on by the war, industry has greatly increased its research effort. There is ample evidence that its dependence on fundamental research has been recognized by the more progressive industrial leaders. Increase in contributions made by industry to universities without exactment of control gives clear indication of this fact. The success of industry in the application of scientific principles to production has popularized science in the public mind until even the politician has perceived its influence. Let us take care that he doesn't kill the goose in his effort to take credit for the golden egg.

Population Growth and the Institute of Food Technologists

CLARENCE BIRDSEYE
Gloucester, Massachusetts

SECOND PRESENTATION OF STEPHEN M. BABCOCK AWARD, SAN FRANCISCO, CALIFORNIA, JULY 11, 1949

This award was presented to Mr. Clarence Birdseye for outstanding contributions to the field of food technology which influence public health through more nutritious food. A jury of I. F. T. members selected Mr. Birdseye, notable pioneer in food preservation, for the second award of this series, which is provided by the Nutrition Foundation. Dr. Frederick C. Blanck was the recipient of the first Stephen M. Babcock Award.

The presentation was made by the retiring I. F. T. President, Mr. H. C. Diehl, at the 1949 national convention of the Institute in San Francisco.

Beyond his broad recognition as an outstanding food technologist, Mr. Birdseye is well known as a naturalist of distinction. The subjects of his publications include low temperature food preservation, ornithology, mammalogy, rodent control, incandescent reflector lamps, and food dehydration.

CLARENCE BIRDSEYE
Pioneer in Food Preservation

I cannot adequately express the surprise and pleasure which receipt of this Award has given me. Both have been magnified many times by my awareness that I am neither a scientist nor a technologist in the sense in which those terms are properly applied to members of the Institute of Food Technologists. I am, in fact, merely a hybrid between a near-scientist, a part-time businessman, and a payer-of-tribute to the U. S. Patent Office—cross-pollinated by the insects of necessity and the winds of experience.

Therefore, in accepting this great honor I shall make no learned address but instead will tell you why I believe that you are all members of the most essential profession on earth and why I think that the Institute of Food Technologists is destined to grow into one of the world's largest and most influential scientific societies.

The essence of the matter is that the world's population is growing faster than ever before and that, if recurrent wars and limitless misery are to be avoided in the future, civilization's major objective must be to furnish all human beings everywhere with an ample and adequate diet. In the past, well-fed peoples have been able to ignore mass starvation in distant populations; but in the shrunken world of tomorrow that will not be possible. The whole globe's food and population must somehow be continuously balanced.

How rapid is this population growth? One hundred years ago, there were one billion human beings. Today there are twice as many. At that rate, there would be sixteen billion men, women, and children in 300 years and two trillion only ten centuries hence—one person for every eight square yards of the earth's land surface.

Obviously food must be produced at an ever-accelerating rate. Where is it to come from? Nobody knows. We can only guess whether, when, where, and how the demand will be met. But it is significant that the wildest estimate yet dared places the ultimate feedable population at only sixteen billion.

The proper nutrition of a greatly-increased world population of course involves many presently unsolvable problems not within the scope of the food industry itself. Tremendous political, religious, social, financial, economic, and logistic difficulties must be met.

But one thing is certain—increased demand for food all over the world will inevitably mean an equally great expansion of the scientific, engineering, and technological phases of the food industry. That is true, because by no stretch of the imagination can future problems be met by means of the tillable acreage, products, equipment, or processes now available to mankind. All our present resources will have to be expanded to the limit and many new facilities, processes, and products—

now only experimental or not yet even conceived of —will have to be developed and put to wide use.

To accomplish our task of getting adequate food into future billions of human stomachs throughout the world, we shall need the aid of almost every form of science and engineering. As just one example of the complexity of the problem, let me point out that only the men of medicine can show us how to conquer the tsetse fly and so open to agriculture the earth's largest virgin potentially farmable area—central Africa.

What does all this have to do with our own I. F. T.? Just this. We are not the "usual" kind of scientific society whose members are all of one ilk—chemists, mechanical engineers, botanists, epidemiologists, agriculturalists, or what have you. On the contrary, our Society was founded to embrace representatives of many sciences, arts, and industries connected with the production, preservation, distribution, and consumption of food. We are unique in the breadth of our membership.

Let's continue, and even expand, the remarkably broad objectives of our founders and draw into our membership selected representatives of many additional groups having to do directly or indirectly with human nutrition. By so doing, we shall realize fully our truly unlimited potentialities for benefiting the world in which we live and improving the material and spiritual opportunities open to our members.

The Use of a Semi-Automatic Moisture Tester for Cheese and Cheese Products [a]

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A new moisture tester, called the semi-automatic moisture tester, was found applicable to moisture determinations in hard cheese and process cheese. Results obtained were comparable to those obtained by standard practices.

Limitations of this test included initial expense, absence of accurate standard drying curves for different types of cheese and relatively limited capacity when running a large number of samples.

During recent years attention in the food industry has been given to the development of new moisture tests. Two notable achievements have been the development of electronic methods for determining moisture and the use of semi-automatic ovens. As far as the cheese industry is concerned, the electronic approach would not be applicable at the present time as it is most useful for relatively low moisture content foods. The semi-automatic oven method, though designed for a large number of materials such as foods, minerals, textiles and many others, has not been scientifically tested on dairy products, including cheese.

This investigation concerned itself only with the semi-automatic moisture tester and the main objective was to obtain rate of drying curves on Cheddar and processed cheese and cheese food and to evaluate the method's practicability to the cheese industry.

Principle of the semi-automatic moisture tester. The moisture tester used in this work was the Brabender semi-automatic moisture tester.[b] A picture of this machine is shown in Figure 1.

Moisture testers of this type are stated to possess advantages of accuracy, speed and simplicity. Final moisture tests may be obtained from 10 to 60 minutes, depending upon temperature settings. In addition, no computation is required as final moisture values are read directly from an illuminated vernier in the machine.

In this moisture tester the final weighing is conducted while the pans are in the oven, which is controlled by an electrical contact thermoregulator adjustable from 45° C. to 160° C. This is possible because an analytical balance is built into the machine and when the moisture is driven from the cheese the pan, while still in the oven, is placed on a tripod which acts as one of the arms of the built-in analytical balance.

Only one outside weighing is required. This consists of a constant weight sample of cheese using a constant weight pan on a special rapid weighing-in scale having an accuracy of ± 2 mg.

The oven has capacity for ten samples at one time. These samples can be inserted at any time by means of a turntable, while others are being heated. Some of the ovens are equipped with forced draft systems. Readings can be taken to 0.05 percent.

Experimental Methods

Comparative moisture tests were obtained by using the forced draft semi-automatic moisture tester [b] shown in Figure 1 and an atmospheric oven. The latter was considered the reference standard moisture test for this work and the cheeses were dried at 101° C. for 24 hours in this oven.

In the semi-automatic moisture tester small aluminum dishes 5/8" high and weighing 11.5 grams were used. Temperatures used in this oven were 130°; 135°; 140° and 150° C.

The samples were cut from a cross-section portion of the cheese and well minced. A representative sample of cheese weighing approximately 2 to 3 gms. was used

[a] This investigation was aided by a grant from the National Cheese Institute. The authors are indebted to Mrs. Catherine Verwoert Work and Mr. Allan Leventhal for their aid in making many of the chemical analyses.

[b] Manufactured by Brabender Corporation, Rochelle Park, N. J.

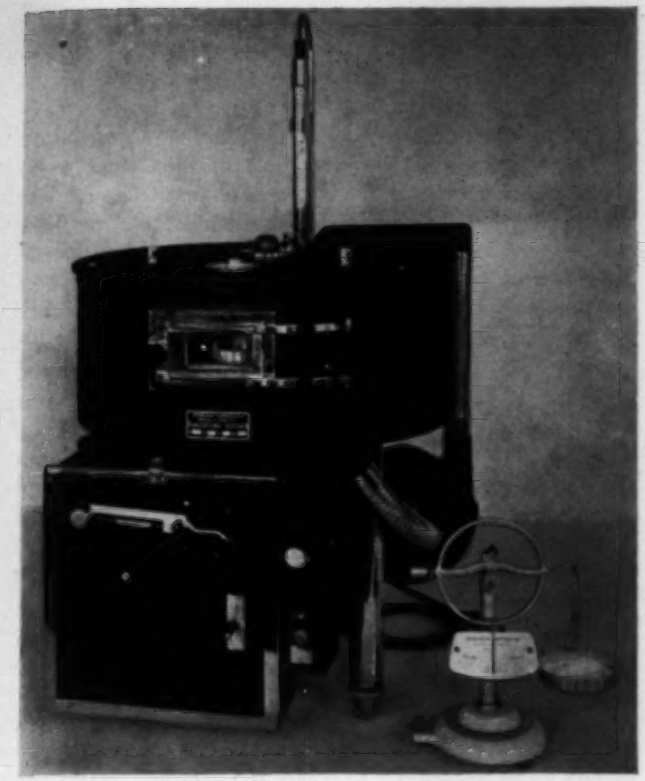

FIG. 1. The Semi-Automatic Moisture Tester with Special Rapid Weighing-in Scale.

for the atmospheric oven method and exactly 5 grams ± .01 for the semi-automatic moisture test.

Experimental Results

Rates of Drying Curves Obtained on American Cheddar, Mild Process Cheese Food and Sharp Process Cheddar Cheese. A number of American Cheddar cheeses were tested for moisture by the two methods. In Figure 2 are shown rate of drying curves obtained at the four different temperatures used in this study. In small inserted tables in Figure 2 are shown the average critical time and temperature required in the semi-automatic moisture method to correspond with the average moisture test obtained by the standard reference atmospheric oven method. These data and graphs show that temperatures ranging from 130° C. to 150° C. require 60 to 13 minutes for equivalent drying. Drying times of one hour or over may be too long for practical consideration.

Similarly in Figure 3 are shown the rate of drying curves and critical average time and temperature for mild process and sharp process cheese. The number of process cheese and cheese foods tested were not as great as natural cheese, but this is compensated for by the greater uniformity of process cheese. It was noted, Figures 2 and 3, that process cheeses and cheese food require longer heating periods to drive off the moisture when compared to natural cheese at the same temperature. This is especially true in the case of mild process cheese food. Figure 3 shows that for process cheese and cheese food temperatures of 130° C. and 135° C. require over a 60-minute heating period in this study.

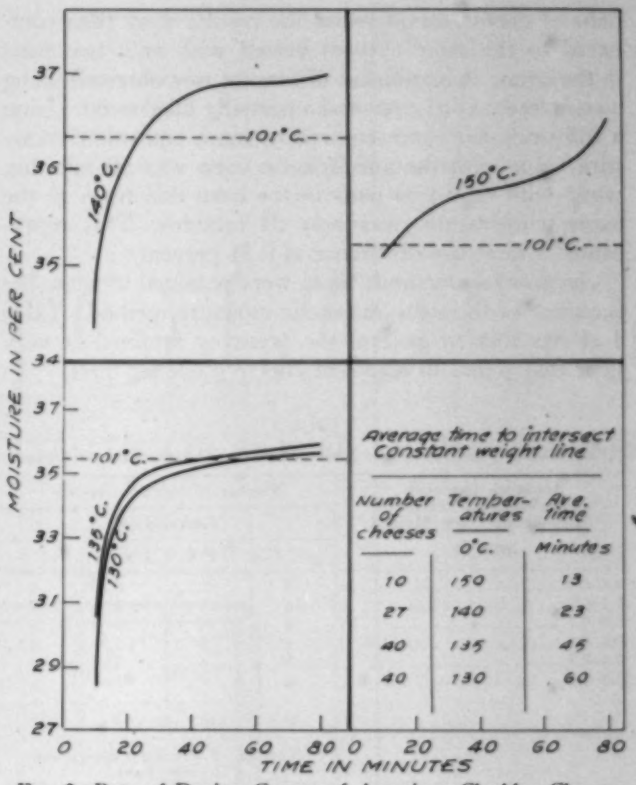

FIG. 2. Rate of Drying Curves of American Cheddar Cheese.

As a result, higher heating temperatures may be more practical for this type of product.

The effect of a full and a partially filled oven. Tests were conducted in which the moisture content was determined by having the semi-automatic oven full with 10

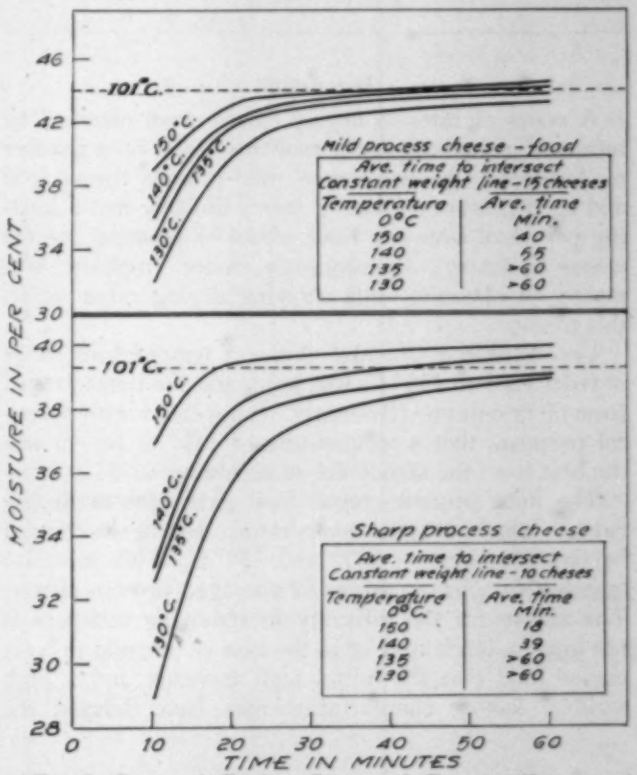

FIG. 3. Rates of Drying Curves of Process Cheese and Processed Cheese Food.